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I. CONTRIBUTIONS TO A KNOWLEDGE OF THE LICHENS OF MINNESOTA—III. THE ROCK LICHENS OF TAYLORS FALLS.

Bruce Fink.

THE COMPOSITION AND ORIGIN OF THE FLORA.

The lichens listed in this paper were collected during two regular annual excursions of the Summer School of the University of Minnesota. The date of collection of all numbers up to 92 is August 15, 1896, and the plants were collected by Professor Conway MacMillan and the writer, on the Algonkian igneous rocks of the Interstate Park, or on earth or branches in the crevices of the rocks. On the 14th of August, 1897, I accompanied another excursion to examine the lichens growing on the Cambrian sandstone exposures near the park. Numbers 93 to 119 were collected by me during this second trip, and more species were noted on the sandstone, which had been collected the year before on the igneous rocks. In all, 24 lichens were found growing on both sandstone and igneous rocks, 22 on the igneous rocks only, 20 on the sandstone only, 10 on earth in the crevices of the igneous rocks and 2 on roots or branches in the crevices. The last lichen of the list was found on old boards and is recorded here because rare or difficult to detect and new to the State.

It was my intention when I went to the park to publish whatever might be found of interest with the last number of this series of papers. But after observing the field it became apparent that the locality is one of great interest both as to origin and present composition of its lichen flora and that these characteristic floral features could be presented best in a separate paper. A little observation showed that the tree lichens do not differ to any noticeable extent from those about Minneapolis, and I consequently confined my collecting to the igneous rocks and sandstone. There are rocks near the park containing lime, but they did not seem to support any lichens of special interest.

The collecting was all done on the Minnesota side of the river for the reason that the erosion of the valley has been such as to leave better exposures of rock here than on the Wisconsin side. I had collected from excellent exposures of igneous rocks in New England and have since visited similar ones in various parts of northern Minnesota; but I have never seen any other equally limited area of rock exposure that aroused so much interest, because of richness of lichen flora and evidence of migrations and struggle, as did this little area, set aside for an interstate park. During the trip of 1897 I noticed that the constant tramp of feet had begun to kill out the lichens in many places so that the impression of richness is beginning to fade, and the botanist must soon seek some place near by, if such exists, where he may study this rich flora in its natural beauty.

Professor E. E. Edwards, of Lancaster, Wisconsin, writes thus of the lichens found in the park: "The rocks of the Dalles owe their beauty and variegated tints not alone to the metal oxides, or to the feldspar or hornblende chiefly composing them, but to the growth of minute lichens upon their surfaces, and these vary in color according to the dryness or moisture of the atmosphere. We have, therefore, in these, through sunshine and shadow and the varying seasons, an endless and almost kaleidoscopic play of colors that makes them alike the delight and despair of the artist." The little area, being one of great natural beauty and set apart for an interstate park, will always attract thousands of visitors annually and I hope to present in this paper thoughts which will enable the botanist who has a fair knowledge of lichen species and their distribution to see in this wonderful lichen population something of far greater interest than mere beauty.

Some comparisons between the locality now under consideration and others will best show its richness in rock lichens. The area examined covers only a few acres of surface and gave 66 lichens growing on rocks as a result of two days' collecting. The whole region about Minneapolis when more thoroughly worked only furnished 30 saxicolous lichens, and the whole of Fayette county, Iowa, only 50. The latter region is surely better than the average for rock lichens, and I have studied it for six years. Probably however, the fact that I have not looked so closely in the last two localities for lichens not strictly characteristic of rocks, but still growing on them occasionally, about offsets the limited time spent in examining the area forming the basis of the thoughts here presented, so that the numbers given above, save for difference in areas covered in the three instances, may still be taken to represent, approximately, relative richness in rock lichens. But again, the Taylors Falls area, with one possible exception, gave me more such lichens collected in the two days than are recorded in any State list hitherto published.

The igneous rocks at Taylors Falls are essentially like those which outcrop occasionally between this place and Lake Superior, and the fact that Taylors Falls is practically the southern limit of outcrop of these rocks furnished the first suggestion of the interest involved in an analysis of their lichen-flora. Of the 79 species and varieties collected, only 8 are plants not yet found further south in Minnesota or Iowa. These 8 I have also found along Lake Superior, and they are species not commonly occurring further south except at high elevations. These are *Biatora rufonigra* Tuck., *Lecidea albocærulescens* Schær., three forms of *Buellia petræa* (Flot., Koerb.) Tuck., *Umbilicaria dillenii* Tuck., *Nephroma helveticum* Ach. and *Ephebe solida* Born., all forms found on the igneous rocks and none of them on the sandstone. Subtracting the 8 species and varieties leaves 58 rock lichens, nearly all of which occur in other portions of the southern half of Minnesota, but not all on rocks. Those not known to flourish on rocks in other parts of the State grow on them here under unusually favorable conditions to be explained below.

What has already been stated, especially the last paragraph above, merely suggests the problems of interest which I shall attempt to discuss and which involve a knowledge of geological conditions present and past, as well as acquaintance with lichen-species and their distribution in general. For the geological data concerning this area, I have relied largely on the researches of Dr. Charles P. Berkey, who has recently studied the region including Taylors Falls in detail, and who is therefore especially able to give the information needed for my purpose. The questions which I shall consider below are those which thrust themselves upon me as I observed and studied this extremely interesting lichen-flora; and though the area is a small one, the questions involved are, it seems to me, none the less worthy of consideration when we notice that it is one of a series of similar areas where certain floral elements have become isolated and gradually killed out by others.

The 8 species commonly found farther north have evidently migrated southward, and there are at least two views as to time and method or cause of migration worthy of consideration. First, the northern species might perhaps have migrated from Lake Superior along the exposures of igneous rocks extending from the lake to four or five miles below Taylors Falls in quite recent times, long after the retreat of the last glacier. Second, they seem undoubtedly to be the remnant of a flora driven south, doubtless from some region far north of Lake Superior, by the advancing glaciers and left stranded on favorable substrata at Taylors Falls as the southern extremity of a flora migrating south before the glacier or more probably migrating north on the return of post-glacial climate in the north temperate zone.

The outcrops of the igneous rocks between Lake Superior and Taylors Falls are not frequent enough to make either theory seem very plausible; but the second is reasonable since, under the influence of slow decrease in temperature to the southward, migration would naturally follow increasingly favorable climatic conditions in that direction even if the outcrops were not more frequent than now. However, it seems probable that at the time of the first glacial advance the outcrops were much more numerous than now. Also, the rock lichens, now found on the igneous rocks only, doubtless found a foothold on the sandstones on the line of retreat under the more favorable climatic conditions of glacial times. The numerous boulders of the same igneous rocks, scattered over the ground by the glaciers could help in the advance southward of some of the species since glacial times, but hardly of those seldom or never found on boulders, as the *Umbilicaria* listed. On the whole, it seems doubtful whether a single one of the 8 northern species has migrated southward in post-glacial times under increasingly unfavorable conditions as to climate and substrata.

As the remnant of a lichen-flora driven south by glaciers, these plants must either have been stranded during a late glacial advance, as during a slight advance during, or more probably after, the Wisconsin stage; or more probably have been driven further south than their present position by each of the earlier stages, or ages as the case may be, and retreated with each return of interglacial conditions. The 8 northern species at Taylors Falls are thus either a few of a former flora which has doubtless partly died out and partly migrated northward, or possibly a few species which migrated to the locality from the mountains to the east and west during a late glacial stage, as stated above, or even after the final retreat of the ice. Igneous rocks are not supposed to have been exposed over the region covered by the glaciers south of the area now under consideration at the time of the first glacial advance, but sandstone no doubt outcropped frequently and probably further south than the glaciers extended. For a long period after each glacial retreat the surface was no doubt thickly strewn with rocks left by the melting ice, and these rocks would furnish abundant substrata for a retreat of the saxicolous lichens to the north. These same boulders, now largely covered, would partly remain at the surface during interglacial conditions and furnish sufficient foothold for the organisms to remigrate during a subsequent advance of the ice, thus taking the place of the sandstone where it was covered by previous drift deposits. Thus several migrations, alternately southward and northward, probably followed in succession, and we are studying the last stage in the last northward retreat in this not yet completed series. Of course, it is apparent that the *Umbilicaria* and many other lichens not now found at Taylors Falls might have flourished on the sandstone and later on the boulders at a time when the climate was more favorable for northern species than now, at and south of the area under consideration, both as to temperature and moisture, and that they could have migrated readily enough with the advances and retreats of glacial conditions. What species of the rock lichens were able to endure these cycles of migration and what were killed out is not easy to conjecture. However, it seems certain that the region was left barren of such life and repopulated several times, and it is extremely probable that enough species survived the migrations, or possibly in part flowed in from the east or west as stated above, to give an arctic or subarctic flora at Taylors Falls for a time after the close of the ice age.

Since the time when this last northern lichen-flora became established in the region about Taylors Falls, there has been a gradual change toward a lichen-flora characteristic of the northern United States at the present time. No doubt the 8 northern species now found on the igneous rocks are being rapidly replaced by the more numerous species, which are better adapted to present climatic conditions. With the exception of the *Nephroma*, the 8 species persisting, all lichens confined wholly to rocky substrata, or essentially so, and being therefore favorably situated as to substrata, have persisted longest against unfavorable climatic conditions and the onslaughts of the species which are to-day surely replacing them. *Nephroma*, which is arboricolous as well as rupicolous, furnished only a few small, sterile specimens clinging to mossy rocks. *Ephebe* was seen in one spot only, and, so far as I could ascertain, *Umbilicaria* persists only in a few cool, damp or shaded spots. The three species named above, not closely attached to the rocks, would naturally succumb to unfavorable conditions sooner than those named below, and all of the three former are sterile and apparently just on the verge of extermination in the locality. The other three species all grow closer to the rocks and are all abundantly fertile. *Biatora* seems to be rare and is not strictly crustaceous as are the other two. *Buellia* is the most common of the 8 northern species and is one of two that would be expected to persist longest because of its strictly crustaceous habit. *Lecidea* is as thoroughly crustaceous, but not so common as the *Buellia*. It must be noted that the latter plant shows locally the strong tendency to vary so characteristic of organisms attempting to adapt themselves to change in environment. Doubtless this variation has aided the plant somewhat in succeeding best of all the present or former more northern species of the locality against adverse climatic conditions. Whether or not the three forms of the species listed arose from one in this locality has no particular bearing in the matter as could be easily shown. Also the distribution of the three forms is so little known that knowledge as to which particular form is most common locally would not show whether it is one most commonly persisting in temperate regions or not.

It is interesting to note the time involved in the establishment of the Arctic flora and the change from this to the present essentially temperate flora. According to Professor N. H. Winchell's views as to the recession of St. Anthony falls, the final retreat of the glaciers from the region occurred about 8,000 years ago. Thus it seems that the succeeding 8,000 years must have sufficed for the establishment of a more or less rich Arctic flora and the gradual change to present floral conditions. The relative times involved in the establishment of the first flora and the gradual change to the present cannot be arrived at, since the richness of the first cannot be known, and we cannot yet be sure that a portion of the species migrating southward were not killed out in some portions of the series of migrations, so that some portion of the northern species that became established in the locality would have to migrate toward the center of the continent from the southward-extending mountains already mentioned. Light on this last supposition, which can only be fully obtained, it seems to me at present, by a study of the lichen flora of the British possessions far to the north of Minnesota, would be extremely interesting.

The absence of the 8 northern lichens from the sandstone may be easily explained, since it seems that the present sandstone surfaces exposed between Lake Superior and Taylors Falls are largely or entirely due to post-glacial erosion. If some of these surfaces are admitted to be as old as the time of the last glacial retreat, doubtless Arctic species grew on them at some time subsequent to that retreat. If this be true, it is yet easy to account for the failure of these lichens to persist on the sandstones as well as on the igneous rocks, since the lichen-flora of these porous and easily eroding surfaces must be a comparatively changeable and transient one, so that whatever such species once inhabited them would now be replaced by species more characteristic of present climatic conditions. After the final retreat of the ice and the change to present conditions of temperature and moisture began, the rapidly eroding surfaces would begin to lose their northern species and be resupplied by those at hand on other substrata at once, while those on igneous rocks could be replaced, mainly, at least, only by a fierce and long-continued struggle between the Arctic and temperate floral elements. The large number of species found on the sandstones is at first surprising, for while the igneous rocks are much richer in individual lichens, they show no appreciable advantage in species. The softer texture of the sandstone, which caused the more rapid destruction of the species growing under unfavorable climatic conditions, has also brought this condition. To be a little more explicit, while on account of their rapid erosion a large number of individuals cannot become established on them and remain long enough to constitute a flora rich in individuals, yet because of the porous character of the sandstone more of the species characteristic of temperate regions have doubtless already become established on them in one place or another than on the igneous rocks.

While the 8 species and varieties so fully treated above are of special interest there are some thoughts concerning the other 70 (excluding the last one listed) that must not be lost sight of. As to distribution they are a heterogeneous group, 30 of them being pretty generally distributed over the United States and Canada, 24 being limited so far as their distribution is known to the territory east of the Rocky mountains, 7 being thus far found only in the northern United States and Canada and 5 occurring throughout the United States. The North American distribution of the last 4 here considered is so little known that nothing can be definitely stated of it. Of these 70 all but 4 or 5 occur on rocks in some other portion of North America, but only 15 are strictly rupicoline. Of the other 55, some, though more characteristic of rocks, are more or less frequently found growing on other substrata; and others actually prefer other substrata and are growing on rocks here under unusually favorable conditions. These lichens, like the others, are of course the descendants of a race that has migrated several times. Nearly all of them being species also occurring in Europe, it is certain that they were represented by like species during early Tertiary times, far to the north where our continent was then connected with the Eastern continent on both sides. The coming of a cooler climate and finally of glacial conditions inaugurated the series of migrations. Finally after the last retreat of the glaciers began, the 55 species, because of their adaptation to more than one substratum, would follow the retreat more surely and more rapidly and thus more certainly and sooner reach a given locality and begin to replace a flora growing under unfavorable conditions. To just what extent the arctic flora would become established before these species would come in and begin to replace it can not be stated since the rate of retreat of the glaciers relative to the rate of migration of essentially stationary organisms is not known.

In the second paper of this series, I accounted for the comparative scarcity of lichens about Minneapolis by dryness of climate and stated that, were it not for peculiarly unfavorable conditions as to rock-formations, this explanation would require a larger per cent. of the total number of lichens found there to occur on the rocks because of greater amount of moisture near the ground. The annual precipitation at Osceola Mills for the last six years has been 31.271 inches, while at St. Paul it has been 28.997 inches. The former place being only seven miles from Taylors Falls, the figures may be taken to show that the precipitation in the locality now considered is about 2.274 inches more per annum than that at Minneapolis. Hence we have at Taylors Falls essentially the same conditions as to moisture of atmosphere as at Minneapolis. However at the former place we have the extensive rock-formations necessary for the establishment of the plants, and we find further that the igneous rocks are favorably situated for lichen development in that they lie along a river course formerly better shaded than now and where moisture has been abundant in spite of comparative dryness of atmosphere. Also this flora was doubtless largely established when the climate was not so dry as now and is persisting against conditions less favorable than formerly existed. Moreover the 8 persisting northern species add to the number strictly characteristic of present climate and give the locality a further advantage over Minneapolis and vicinity. Doubtless study of the whole lichen-flora about Taylors Falls would show that between 30 and 50 per cent. of the lichens grow on rocks as compared with 12 per cent. at Minneapolis. The slight advantage in annual precipitation of moisture for the former locality, of course, adds slightly to the relative richness in rock lichens, but this is insignificant as a cause when compared with the elements considered above.

Another objection of doubtful value to the first proposition suggested to account for the invasion of the northern rock-floral elements is that, though there is a continuous line of conifers from Lake Superior to Taylors Falls, the northern tree-inhabiting lichens are wholly absent at Taylors Falls, or so scarce as to escape notice. The coniferous trees are not so conspicuous a part of the flora at Taylors Falls as in Pine county, fifty miles north. No doubt at least a part of the tree lichens characteristic of more northern regions, and now almost certainly to be found in Pine county, have extended down to this location in post-glacial times, as the conifers are abundant from Lake

Superior down to the southern part of this county, and with substrata abundant, they could do so in spite of unfavorable climatic conditions. They have apparently failed to advance as far as Taylors Falls, because of favorite substrata becoming somewhat scarce, and an increase of unfavorable conditions as to temperature and precipitation. I am aware that the glaciers probably retreated slowly enough so that forests could spring up and furnish substrata for the retreat of species driven south in glacial times, before they would die out at the south on account of the return of warm climate, and that whatever northern tree lichens exist in the pineries fifty miles north, could be accounted for, wholly or in part, as having migrated from the south. Yet I am quite convinced that there has been a circulation of arboreous lichen-floral elements, between Lake Superior and Pine county, in post-glacial time, which has not extended to Taylors Falls, to any easily observable extent surely, though conditions as to substrata are much more favorable for such lichens to move southward from the lake than for the rock lichens.

Not a single species of northern lichen was found in the rock crevices or soil studied. I have noticed how in regions recently burned the soil becomes literally covered in places by lichens of various genera in five to fifteen years, and there can be no doubt that earth lichens took possession of the glacial drift rapidly after the retreat of the ice began. However, from the very fact that lichens spring up rapidly on earth, the species characteristic of temperate climate would the more quickly take possession of the present limited amount of soil available for lichen growth, and whatever additional amount that was available when the strife began between arctic and temperate earth lichens, and the more rapidly kill out the northern species once inhabiting the drift.

A consideration of the statements made in the last two paragraphs and various other portions of this paper points to the conclusion that a study of the whole lichen-flora of the area between Taylors Falls and Lake Superior is essential to a better understanding of the problems herein considered. In the next paper of this series, in which I shall consider the lichen-flora of the Lake Superior region, I shall be able to show additional reasons for the study of this territory. It is one of rapid transition in lichen-flora, and after a study of the areas to the north and south of it, questions of extreme interest have been suggested to me which can only be solved by a study of this flora.

The principal conclusions are as follows:

(1) The region considered in this paper is an important one for the study of lichen-flora because of position, and geological relations past and present.

(2) The flora considered is one of great interest as to origin and present composition and as to evidence of struggle between flora elements.

(3) The present lichen-flora is composed of arctic, sub-arctic and temperate florae elements in which the last have long since gained the advantage and are killing out the others.

(4) It is not supposed that the northern species migrated south in post-glacial times, but rather that this flora is one that followed the last retreat of the glaciers and was for a time essentially arctic, having since changed to its present composition.

(5) Reasons for the above conclusions are as follows:

 (*a*) Southward migration would more naturally result from the decrease of temperature to the south inaugurated by the on-coming of a glacial climate and would thus go on even though suitable substrata might be somewhat scarce.

 (*b*) But during the glacial advances rocky substrata were doubtless more numerous than now, a condition adding to the ease of migration.

 (*c*) Under the influence of increasingly favorable climatic conditions to the south, the plants would take more easily to unfavorable substrata and migrate more readily on this account also.

 (*d*) The 8 northern lichens are all but one essentially rock lichens and are, therefore, the ones that would be expected to persist longest.

(6) The northern floral elements considered may have been driven south during a late glacial advance not extending quite to the region, but more probably have been forced to migrate further south several times and migrate north as many times.

(7) The migrating plants may have been in part or wholly killed out in some part of the series of migrations southward in the Mississippi Valley, so that the present northern floral element would have to flow in from the mountains to the east and west, but more probably found sufficient substrata and were not killed out in the southward migrations in the valley.

(8) The time involved in the change from arctic and sub-arctic to temperate flora is probably about 8,000 years. The relative times occupied in the establishment of the northern flora and the change to the temperature one can not be estimated at present.

(9) The absence of the northern floral elements from the sandstone is due partly to the fact that many of the surfaces of sandstone exposures are post-glacial. If some are as old as the last retreat of the glaciers from the region, the absence is still easily explained since the surfaces are easily eroded and porous so that floral changes go on rapidly on these rocks.

(10) Lichens are not individually numerous on the sandstones because of this easily eroding nature which causes rapid change and destruction; yet a large number of species become established in one place or another on them because lichens quickly gain a foothold.

(11) The other 70 lichens of the rocks are not so characteristically rock lichens and would migrate more easily and rapidly, and the more quickly reach a locality and replace an established flora existing under unfavorable conditions, because not confined to one substratum.

(12) The rock lichen-flora of the locality is extremely rich because of abundance of rocks, location in a river valley where shade and moisture have been plentiful and geographically where the 8 northern species have persisted to increase the number more characteristic of present climatic conditions.

(13) In substantiation of the method used to account for the present composition of the flora, I have attempted to show that the absence of tree and earth lichens from the locality tends to prove its correctness.

(14) In view of work already done at Taylors Falls and along Lake Superior, the study of the region of rapid transition in lichen-flora between is greatly to be desired.

I am under great obligations to Dr. Charles P. Berkey for information concerning present and past geological conditions of the area studied. My thanks are also due to Professor Conway MacMillan for data concerning the distribution of the Conifers between Taylors Falls and Lake Superior and to Mr. Geo. H. Hazzard, of Taylors Falls, for the figures of annual precipitation of moisture in the vicinity of Taylors Falls.

LIST OF SPECIES AND VARIETIES.

1. **Ramalina calicaris** (L.) FR. var. **farinacea** SCHÆR.
On igneous rocks and sandstone, no. 83.

2. **Usnea barbata** (L.) FR. var. **florida** FR.
On igneous rocks and sandstone, no. 45.

3. **Usnea barbata** (L.) FR. var. **rubiginea** MICHX.
On sandstone, no. 117.

4. **Theloschistes lychneus** (NYL.) TUCK.
On igneous rocks and sandstone, no. 64.

5. **Theloschistes concolor** (DICKS.) TUCK.
On sandstone, no. 102.

6. **Parmelia perforata** (JACQ.) ACH.
On igneous rocks, no. 71.
Not previously reported from Minnesota.

7. **Parmelia crinita** ACH.
On igneous rocks, no. 66.

8. **Parmelia borreri** TURN.
On sandstone, no. 111.

9. **Parmelia saxatilis** (L.) FR.
On igneous rocks and sandstone, nos. 52 and 67.

10. **Parmelia olivacea** (L.) ACH.
On igneous rocks, no. 60.

11. **Parmelia caperata** (L.) ACH.
On igneous rocks and sandstone, no. 50.

12. **Parmelia conspersa** (EHRH.) ACH.
On igneous rocks and sandstone, no. 49.

13. **Physcia speciosa** (WULF. ACH.) NYL.
On igneous rocks and sandstone, no. 63.

14. **Physcia aquila** (Ach.) Nyl. var. **detonsa** Tuck.
On igneous rocks and sandstone, nos. 42 and 86.
Not previously reported from Minnesota.

15. **Physcia pulverulenta** (Schreb.) Nyl.
On igneous rocks and sandstone, no. 73.

16. **Physcia stellaris** (L.) Tuck.
On igneous rocks, no. 2.

17. **Physcia tribacia** (Ach.) Tuck.
On igneous rocks, nos. 55 and 77.

18. **Physcia cæsia** (Hoffm.) Nyl.
On igneous rocks, no. 30.

19. **Physcia obscura** (Ehrh.) Nyl.
On igneous rocks, nos. 5 and 47.

20. **Pyxine sorediata** Fr.
On igneous rocks, no. 48.

21. **Umbilicaria dillenii** Tuck.
On igneous rocks, no. 87.

22. **Nephroma helveticum** Ach.
On igneous rocks, no. 26.
Not previously reported from Minnesota.

23. **Peltigera pulverulenta** (Tayl.) Nyl.
On earth among igneous rocks, no. 15.

24. **Peltigera rufescens** (Neck.) Hoffm.
On earth among igneous rocks, no. 17.

25. **Peltigera canina** (L.) Hoffm.
On earth among igneous rocks and on sandstone, nos. 16 and 28.

26. **Peltigera canina** (L.) Hoffm. var. **spuria** Ach.
On sandstone, no. 119.

27. **Peltigera canina** (L.) Hoffm. var. **sorediata** Schær.
On sandstone, no. 96.

28. **Pannaria languinosa** (Ach.) Koerb.
On igneous rocks and sandstone, no. 20.

29. **Pannaria microphylla** (Sev.) Delis.
On igneous rocks and sandstone, no. 35.
Not previously reported from Minnesota.

30. **Ephebe solida** Born. (?)
On igneous rocks, no. 59.
The specimens were sterile and must be regarded as uncer-

tain as to species. I found the same plant in three or four localities in northern Minnesota.

Not previously reported from Minnesota.

31. **Collema pulposum** (BERNH.) NYL.
On earth among igneous rocks, no. 23.

32. **Collema flaccidum** ACH.
On igneous rocks, no. 43.

33. **Leptogium tremelloides** (L. FIL.) FR.
On igneous rocks, nos. 18, 25, 29 and 61.
Not previously reported from Minnesota.

34. **Leptogium chloromelum** (SEV.) NYL.
On sandstone, no. 109.
Not previously reported from Minnesota.

35. **Placodium elegans** (LINK.) DC.
On igneous rocks and sandstone, no. 53.

36. **Placodium cinnibarinum** (ACH.) ANZ.
On igneous rocks, no. 31 and 62.

37. **Placodium aurantiacum** (LIGHT) NAEG. and HEPP.
On igneous rocks and sandstones, no. 57.
A form with scanty thallus and biatorine apothecia, appearing much like the next.

38. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **sideritis** TUCK.
On igneous rocks, nos. 38, 39 and 91.

39. **Placodium vitellinum** (EHRH.) NAEG. and HEPP.
On igneous rock and sandstone, no. 3.

40. **Lecanora rubina** (VILL.) ACH.
On igneous rocks and sandstone, no. 51.

41. **Lecanora subfusca** (L.) ACH.
On igneous rocks and sandstone, nos. 12 and 115.

42. **Lecanora subfusca** (L.) ACH. var. **coilocarpa**, ACH.
On sandstone, no. 108.

43. **Lecanora atra** (HUDS.) ACH. (?)
On igneous rocks, no. 4.
Not previously reported from Minnesota.

44. **Lecanora hageni** ACH.
On sandstone, no. 118.

45. **Lecanora varia** (EHRH.) NYL.
On igneous rocks and sandstone, no. 68.

46. **Lecanora varia** (EHRH.) NYL. var. **symmicta**, ACH.
On sandstone, no 103.

47. **Lecanora cinerea** (L.) SOMMERF.
On igneous rocks and sandstone, nos. 11, 19, 34 and 70.

48. **Lecanora cinerea** (L.) SOMMERF. var. **lævata**, FR.
On igneous rocks, no. 14.
Not previously reported from Minnesota.

49. **Lecanora fuscata** (SCHRAD.) TH. FR.
On igneous rocks and sandstone, nos. 33, 56, 94, and 106.
Not previously reported from Minnesota.

50. **Rinodina sophodes** (ACH.) NYL.
On igneous rocks and sandstone, nos. 59 and 105.

51. **Pertusaria velata** (TURN.) NYL.
On sandstone, no. 95.

52. **Pertusaria communis** DC.
On sandstone, no. 112.

53. **Urceolaria scruposa** (L.) NYL.
On igneous rocks and sandstone, no: 9.

54. **Stereocaulon condensatum** HOFFM.
On sandstone, no. 93.
Not previously reported from Minnesota. Also not listed before west of New England.

55. **Cladonia mitrula** TUCK.
On sandstone, no. 99.

56. **Cladonia cariosa** (ACH.) SPRENG.
On sandstone, 114.

57. **Cladonia pyxidata** (L.) FR.
On earth among igneous rocks, no. 65.

58. **Cladonia squamosa** HOFFM.
On earth among igneous rocks, nos. 72 and 78.
Not previously reported from Minnesota.

59. **Cladonia cæspiticia** (PERS.) FL.
On earth among igneous rocks and on sandstone, nos. 68[a] and 101.

60. **Cladonia fimbriata** (L.) FR. var. **tubæformis** FR.
On sandstone, nos. 104 and 110.

61. **Cladonia gracilis** (L.) NYL.
On earth among igneous rocks and on sandstone, no. 74.

62. **Cladonia gracilis** (L.) NYL. var. **verticillata**, FR.
On sandstone, no. 116.

63. **Cladonia delicata** (EHRH.) FR.
On old wood among igneous rocks, nos. 79[a] and 67.
Not previously reported from Minnesota.

64. **Cladonia rangiferina** (L.) HOFFM.
On earth among igneous rocks, no. 81.

65. **Cladonia rangiferina** (L.) HOFFM. var. **alpestris** L.
On earth among igneous rocks, no. 82.

66. **Cladonia macilenta** (EHRH.) HOFFM.
On old roots among igneous rocks, no. 79[b] and 80[a].

67. **Biatora rufonigra** TUCK.
On igneous rocks, no. 1.
Not previously reported from Minnesota.

68. **Biatora coarctata** (SM. NYL.) TUCK. var. **brajeriana** SCHÆR.
On sandstone, no. 92.
Not previously reported from Minnesota.

69. **Biatora myriocarpoides** (NYL.) TUCK.
On sandstone, no. 100. Habitat unusual, but I cannot distinguish sufficiently between this and my wood specimens to separate them.
Not previously reported from Minnesota.

70. **Lecidea albocærulescens** (WULF.) SCHÆR.
On igneous rocks and sandstones, no. 27.
Not previously reported from Minnesota.

71. **Buellia spuria** ARN.
On igneous rocks, no. 22.
Not previously reported from Minnesota.

72. **Buellia petræa** (FLOT., KOERB.) TUCK.
On igneous rocks, no. 58.
Not previously reported from Minnesota.

73. **Buellia petræa** (FLOT., KOERB.) TUCK. var. **montagnæi** TUCK.
On igneous rocks, no. 89.
Not previously reported trom Minnesota.

74. **Buellia petræa** (FLOT., KOERB.) TUCK. var. **grandis** FLOERK.

On igneous rocks, no. 89[a]. Thallus coarser, more crowded and lighter colored. Hypothallus deficient.

Not previously reported from Minnesota.

75. **Endocarpon miniatum** (L.) SCHÆR.

On igneous rocks and sandstone, no. 41.

76. **Endocarpon hepaticum** HEDW.

On sandstone, no. 97.

77. **Verrucaria fuscella** FR.

On igneous rocks, no. 21.

78. **Verrucaria muralis** ACH.

On sandstone, no. 107.

79. **Thelocarpon prasinellum** NYL.

On old boards, no. 113.

Not previously reported from Minnesota.

II. A METHOD OF DETERMINING THE ABUNDANCE OF SECONDARY SPECIES.

Roscoe Pound and Frederic E. Clements.

In determining the abundance of species, appearances are extremely deceptive. One who has worked over the prairies for many seasons comes to think that he can pick out instantly the most abundant secondary species. Long continued observation in the field stamps a picture on one's mind, and it seems a simple matter to pick out the several species and to classify them in the several grades of abundance with reasonable accuracy. As a matter of fact, this is not possible. After more than ten years of active field work on the prairies, it seemed to the writers that the mental pictures acquired was approximately sufficient to make the reference of the commoner secondary species of prairie formations to their proper grades an easy task. When actual looking at the prairies as the season permitted appeared to confirm the picture already formed, this seemed certain. Closer analysis of the floral covering proved that the conclusions formed from looking at the prairie formations and from long field experience, without actual enumeration of individual plants, were largely erroneous. The psoraleas, prairie clovers and blazing stars would probably occur to all as among the most abundant of the secondary species in the vernal, estival and serotinal aspects of the prairies respectively. When we first addressed ourselves to the task of assigning to each of the various prairie species its proper degree of abundance, it occurred to us at once that we could take a certain species, or certain species, as types for each grade, and use these species as standards by which to measure the others. It proved in the end that the species selected, though of the commonest occurrence and hence familiar from daily observation, were in many cases referred to wrong grades as compared with other species, no less common, but for some reason not so prominent. The difficulty is that the species which appear most prominent in the constitution of the prairies are not necessarily the most abundant.

The prominent-flowered blazing stars and prairie clovers make a much greater impression on the eye than species which are far more abundant, and the same thing is true to a less degree of many other species. To insure accurate or even approximately accurate results, it is necessary to resort to some method of actual count.

Actual count is usually practicable only when copious, gregario-copious or sparse plants are in question. But it is only with respect to such species, which are as a rule secondary in formations, that it is important to determine minutely the grade of abundance manifested.

During the past season, in order to determine the actual quantitative relations of the copious and gregario-copious species, we have made a large number of enumerations of the individual plants of each secondary species present in plots five meters square in characteristic formations of each of the four phytogeographical regions represented in Nebraska. The plot used, five meters square, is as large as can be used to insure accuracy in counting. The deficiences resulting from the small size of the plots are corrected by taking a large number of plots at each station and averaging the results. There is a surprisingly close agreement in figures obtained from plots in widely separated stations in the same district, provided reasonable care is taken to locate them in typical situations.

By way of illustration, a number of observations are given in full. These are not averages, but are the actual counts as taken in the field. The two immediately following were taken on the prairie 14 miles northeast of Lincoln in the prairie grass formation (*Sporobolus-Koeleria-Panicum*). The second was made about 400 yards distant from the first.

Amorpha canescens	387
Aster multiflorus	223
Antennaria campestris (16 patches)	209
Solidago rupestris	101
Helianthus rigidus	97
Kuhnistera candida	43
Kuhnistera purpurea	31
Brauneria pallida	24
Solidago rigida	19
Kuhnia glutinosa	8
Comandra umbellata	7
Rosa arkansana	2

(2)

Amorpha canescens	368
Aster multiflorus	395
Antennaria campestris (6 patches)	154
Solidago rupestris	105
Helianthus rigidus	63
Kuhnistera candida	26
Kuhnistera purpurea	22
Brauneria pallida	19
Solidago rigida	16
Rosa arkansana	8
Solidago rigidiuscula	5
Gerardia purpurea	3
Laciniaria scariosa	2
Erigeron ramosus	1

Linum rigidum was prominent, but did not occur in either of the plots, and in comparatively few of those laid out.

In a large number of plots, *Amorpha canescens* averaged 309, *Aster multiflorus* 275, and *Antennaria campestris* 12 patches and 145 individuals.

Enumerations were also made in the same formation in the transition area between the prairie region and the sand hill region. The following example is one of a number made south of Broken Bow (Custer County). The formation is the ordinary prairie grass (*Sporobolus-Koeleria-Panicum*) formation, modified somewhat on account of the sandy soil.

Amorpha canescens	291
Aster multiflorus	238
Kuhnistera candida (?)	23
Solidago rupestris	21
Brauneria pallida	17
Helianthus rigidus	12
Kuhnia glutinosa	5

The marked decrease in the number of secondary species and in the abundance of each is characteristic of this transition area.

Another count, made where the prairie grass formation was giving way to the buffalo grass formation on the one hand, and to the bunch grass formation on the other, is interesting. While the prairie grasses (species of *Sporobolus*, *Koeleria cristata* and *Panicum Scribnerianum*) were controlling, there was a strong admixture of *Bouteloua oligostachya*, and two bunches of *Andropogon scoparius* occurred in the plot. The locality was about six miles northwest of the preceding.

Amorpha canescens	192
Kuhnistera occidentalis (?)	26
Solidago rupestris	18
Artemisia gnaphalodes	17
Solidago mollis	12
Solidago rigida	3
Helianthus rigidus	2

The following count, made in the buffalo grass formation, about two miles beyond the one last set forth, shows the latter formation as affected by the near proximity of the prairie gras, formation. The number of secondary species, small as it is, is very large for that formation. Where this count was mades the dominant grass was *Bouteloua oligostachya*. The only other grass was *Schedonnardus paniculatus*, represented by two small patches.

Plantago Purshii	42
Solidago mollis	23
Lygodesmia juncea	5
Lepachys columnaris (dwarf)	3
Eriocarpum spinulosum	2
Grindelia squarrosa	1
Kuhnia glutinosa	1
Lesquerella argentea	1

The constant diminution in the number and abundance of secondary species as one passes from the prairie grass formation of the prairie region to the buffalo grass and bunch grass formations of the transition area and of the sand hill region is well illustrated by these figures. The difference betweeen the prairie grass formation in its ordinary situations and in the transition area, and between the buffalo grass formation of the "range" and the same formation in the transition area is better shown by figures obtained from such enumerations than in any other way. Many other examples of the efficacy of this method in representing changes in the floral covering as one passes from one district to another might be given.

The method of actual enumeration of the individual plants present in plots of a given size makes accurate limitation of the several grades of abundance possible. Of course, this has nothing to do with the mode of disposition of individuals. But given a copious, gregario-copious or sparse species, there still remains something more to be said before the abundance of the species is fairly indicated. Collation of the results of a large number of enumerations has shown that six grades of copious plants may be recognized readily. The first, in which the average number of individuals in a plot five meters square exceeds 200, corresponds to copious.[1] As examples, there may be cited from the prarie formations *Amorpha canescens*, with an average of 309 in the prairie region, *Aster multiflorus* with an average of 275 in the prairie region and about 230 in the sand hill region; from the herbaceous layer of woody formations, *Verbesina alternifolia* (which is almost gregarious at times), with an average of 245. To the second degree (copious[2]) those species may be assigned in which the average number of individuals in a plot is from 150 to 200, such as *Plantago Purshii* (162) in the Peppergrass-Cactus formation in the transition area between the sand hill region and the foot hill region. Those species with an average ranging from 100 to 150 may be assigned to the third degree (copious[3]). Examples are: *Aster sagittifolius*, which has an average of 133 in the herbaceous layer of the Bur-oak-Elm-Walnut formation in the Mississippi basin region and *Solidago rupestris*, which has an average of 104 in the *Sporobolus-Koeleria-Panicum* formation in the prairie region. In the fourth degree (copious[4]) those species may be included which have an average of from 50 to 100, such as *Glycorhiza lepidota* in the river valleys in the sand hill region, where its average is 83. All of the foregoing are of sufficient abundance to be included in the general term "copious," taking the latter to represent a quantitative idea as well as the manner of association of the individuals. Where the average falls below 50 and exceeds 5, we call the species "subcopious." Comparison and collation of statistics has shown that subcopious species fall into two groups, in one, which we call subcopious,[1] the average does not fall below 15. Examples are: *Kuhnistera candida* in the *Sporobolus-Koeleria-Panicum* formation in the prairie region, where it has an average of 18, *Solidago mollis* in the Peppergrass-Cactus formation in the transition area between the sand hill and foot hill regions, where its average is slightly over 20, and *Artemisia gnaphalodes* in the transition between the prairie and the sand hill regions, where its average is 16.

Where the average number in a plot is between 5 and 15, the species is called subcopious.[2] A glance at the list given above will show that these are often very striking components of the prairie formations. Finally, in case the average is below 5 and above .01, or one individual in ten plots, the species is called "sparse." Gregario-copious species may be treated in the same way, giving gregario-copious,[1] etc. *Antennaria campestris* in the prairie grass formations of the prairie region, averaging 12 patches and 145 individuals per plot, would be gregario-copious.[3]

Although this method involves no little labor, especially when applied to social species, as we have been able to do successfully in some cases, such as the Peppergrass in the Peppergrass-Cactus formation, it has furnished results which amply reward the time and work required. By means of such enumerations we have been able to determine many questions with certainty which could only be guessed at otherwise, and we have been able to make more accurate limitations of the regions and particularly the transition areas than we had thought possible.

III. LIST OF FRESH-WATER ALGAE COLLECTED IN MINNESOTA DURING 1896 AND 1897.

JOSEPHINE E. TILDEN.

During the past two years no special effort has been made to collect the algae of the State. Several species have been given particular study in the laboratory and a few others have incidentally been brought to notice. The list comprises only those not heretofore recorded in Minnesota, and is a continuation of the series begun in Vol. I. of this publication. Attention may be called to the comparatively large number of lime-secreting forms.

HELMINTHOCLADIACEÆ (HARV.) SCHMITZ Syst. Uebers. Florid. in Flora 4. 1889.

240. **Chantransia pygmaea** (KG.) SIRDT. Les Batrachospermes. 244, 245. 1884.
Together with *Chaetophora calcarea*, *Dicothrix calcarea*, *Lyngbya martensiana* var. *calcarea* and *L. nana*, forming the calcareous crust on sides of old tank and on twigs in the water.
Minneapolis, Minnesota. October 1, 1895.

241. **Chantransia expansa** WOOD. Contr. Hist. Fresh-Water Algae North Am. 215. pl. 19. f. 2. 1872.
On stones under waterfall. Osceola, Wisconsin. September 15, 1897.

CHARACEAE RICHARD in Humb. et Bonpl. Nov. G. I. 1815.

242. **Chara contraria** A. BR. Schweizer. Char. 15. 1847.
In ditches. Osceola, Wisconsin. August 31, 1895.

243. **Chara foetida** A. Br. Ann. Sci. Nat. Bot. II. **1**: 354. 1834.
In pool formed by spring water. Osceola, Wisconsin. September 15, 1897.

ULOTRICHIACEAE (KG.) BORZI em. DE TONI. Syll. Alg. **1**: 151. 1889.

244. **Hormiscia zonata** (WEB. and MOHR) ARESCH. var. **valida** (NÄG.) RABENH. Fl. Eur. Algar **3**: 362. 1868.

On rocks wet with surf. Grand Marais, Lake Superior, Minnesota. Coll. A. H. Elftman. July 27, 1896.

PALMELLACEAE (DECNE.) NÄG. em. DE TONI. Syll. Alg. **1**: 559. 1889.

245. **Scenedesmus obliquus** (TURP.) KG. Syn. Diat. in Linnaea. 8: 609. 1833.

Grown in aquarium in which water was saturated with nitrous oxide. University of Minnesota, Minneapolis, Minnesota. Emil Sandsten. February 23, 1898.

246. **Chlorochytrium archerianum** HIERON. in Jahres. Schles. Gesellsch. 296. 1887.

In cells of *Sphagnum* which had been kept in the University plant-house six weeks. Osceola, Wisconsin. Coll. Conway MacMillan. September 15, 1896.

247. **Tetraspora cylindrica** (WAHLENB.) AG. Syst. Alg. 188. no. 2. 1824.

Attached to lake bottom, abundant around the outside harbor rocks. Grand Marais, Lake Superior, Minnesota. Coll. A. H. Elftman. July 27, 1896.

248. **Palmella miniata** LEIBL. var. **aequalis** NÄG. Einzell. 67. pl. 4. D. f. 2. 1849.

On submerged rocks and pebbles in slow current. Minnehaha creek, Soldiers' Home, Minneapolis, Minnesota. September 27, 1896.

This species contains calcium carbonate in quantity. It is accompanied by filaments which much resemble *Stigeoclonium* in its transition stage.

ZYGNEMACEAE (MENEGH.) RABENH. Fl. Eur. Algar. **2**: 228. 1868.

249. **Mougeotia parvula** HASS. var. **angusta** (HASS.) KIRCHN. Alg. Schles. 128. 1878.

Grown in aquarium in which water was saturated with nitrous oxide. University of Minnesota, Minneapolis, Minnesota. Emil Sandsten. February 23, 1898.

RIVULARIACEAE RABENHORST Fl. Eur. Algar. **2**: 2. 1865.

250. **Calothrix parietina** (NÄG.) THUR. Ess. Class. Nostoch. in Ann. Sci. Nat. Bot. VI. **1**: 381. 1875.

On stone sides of fountain, breaking up in small fragments when peeled off. Kenwood, Minneapolis, Minnesota. August 3, 1895.

251. **Dichothrix calcarea** TILDEN Am. Alg. Cent. II. no. 165. 1896. Bot. Gaz. **23**: 95–104. pl. 7–9. F. 1897

Forming a part of the lime incrustation which covers sides of wooden tank. With no. 240. Minneapolis, Minnesota. October 1, 1895.

252. **Rivularia biasolettiana** MENEGH. in Zanardini Syn. Alg. in mari Adriatico collect. in Reale Acad. Sci. Torino. II. IV. 42. 1841.

On rocks at edge of lake. Big Stone lake, Dakota. Coll. David Griffiths. October 4, 1895.

253. **Gloeotrichia pisum** (AG.) THURET. Essai de class. Nostochinées in Ann. Sci. Nat. Bot. VI. 1: 382. 1875.

Floating on surface of water in large quantity. Lake Minnewaska, Glenwood, Minnesota. Coll. Elizabeth H. Foss. August, 1897.

NOSTOCEAE KÜTZ Phyc. gen. 203. 1843.

254. **Anabaena azollae** STRASB. Bot. Prakt. 341. f. 130. 1887.

In chambers in the leaves of *Azolla Caroliniana*. University plant-house, Minneapolis, Minnesota. September 15, 1896.

255. **Anabaena cycadearum** REINKE, Bot. Zeit. **37**: 473–476. pl. 6. f. 1–5. 1879.

In roots of *Cycas revoluta*. University plant-house, Minneapolis, Minnesota. December 20, 1896.

256. **Anabaena flos-aquae** (LYNGB.) BRÉB. in Brébisson et Godey. Algues des environs de Falaise. 36. 1835.

Floating in abundance on surface of water. Cedar lake, Hennepin county, Minnesota. Coll. Miss M. G. Fanning and H. B. Humphrey. October 28, 1897.

VAGINARIEAE GOMONT in Morot, Journ. de Bot. **4**: 351. 1890.

257. **Schizothrix rupicola** TILDEN. Am. Alg. Cent. II. no. 175. 1896. Bot. Gaz. **23**: 95–104. pl. 7–9. F. 1897.

Bare and dry sandstone cliffs. Soldiers' Home, Minnehaha Falls, Minnesota. Coll. C. W. Hall. September 28, 1896.

258. **Schizothrix lardacea** (CESATI) GOMONT. Monogr. des Oscill. in Ann. Sci. Nat. Bot. VII. **15**: 311. pl. 8. f. 8, 9. 1892.

In a large bottle of distilled water left standing for several months. Botanical laboratory, University of Minnesota, Minneapolis, Minnesota. 1896. Det. by Gomont.

LYNGBYEAE GOMONT Ess. class des Nostocacées homocystées in Morot Journ. de Bot. **4**: 353. 1890.

259. **Lyngbya martensiana** MENEGH. var. **calcarea** TILDEN. Am. Alg. Cent. II. no. 178. 1896. Bot. Gaz. **23**: 95–104. pl. 7–9. F. 1897.

With no. 240. Minneapolis, Minnesota. October 1, 1895.

260. **Lyngbya nana** TILDEN. Am. Alg. Cent. II. no. 179. 1896. Bot. Gaz. **23**: 95–104. pl. 7–9, F. 1897.

With no. 240. Minneapolis, Minnesota. October 1, 1895.

261. **Phormidium valderianum** (DELP.) GOMONT Monogr. des Oscill. in Ann. Sci. Nat. Bot. VII. **16**: 167. pl. 4. f. 20. 1892.

In arm of Mississippi river (old channel), St. Paul Park, Minnesota. Coll. E. M. Freeman, October 3, 1897.

With *Oscillatoria geminata*, *O. tenuis* var. *tergestina*, *Phormidium valderianum*, and species of *Chroococcus*, Palmellaceae, *Coccochloris*, *Rhaphidium*, *Polycystis* and *Scenedemus*. Det. by Gomont.

262. **Oscillatoria geminata** MENEGH. Consp. Algol. euganeae. 9. 1837.

With no. 261.

263. **Oscillatoria tenuis** Agardh. Alg. Dec. 2:25. 1813.
With no. 261.

264. **Gloeocapsa calcarea** n. sp.
Forming a calcareous crust, light gray to light aeruginous in color, 2–3 mm. in thickness; cells 6–9 mic. in diameter, 4–16 united in families; families 25–50 mic. in diameter; sheath colorless, somewhat thin; cell-contents aeruginous, granular.
Associated with several other lime-secreting algal forms.
On boards where spring water from trough drips down constantly. Osceola, Wisconsin. September 15, 1897.

IV. CORRECTIONS AND ADDITIONS TO THE FLORA OF MINNESOTA.

A. A. Heller.

Chenopodium Boscianum Moq. Enum. Chenop. 21. 1840.

This species should be stricken from the list of Minnesota plants, as no specimen of it has yet been reported from the State. Sheldon's "1555, Lake Benton," as well as specimens from other localities, quoted in the Metaspermæ of the Minnesota Valley, probably belong to *Chenopodium album*.

Sophia pinnata (Walt.) Britton, Ill. Fl. 2: 145. 1897.

Erysimum pinnatum Walt. Fl. Car. 174. 1788.
Sisymbrium canescens Nutt. Gen. 2: 68. 1818.
Descurainia pinnata Britton, Mem. Torr. Bot. Club, 5: 173. 1894.

The plants referred to this species in the Metaspermæ of the Minnesota Valley, under the name of "*Sisymbrium multifidum*," belong to *Sophia incisa*, with the exception of Sheldon's "1406, Lake Benton," and "Taylor, 1044, Glenwood," which are specimens of *Sophia Hartwegiana*. *Sophia pinnata* does not occur in Minnesota.

Potentilla leucocarpa Rydberg, in Ill. Fl. 2: 212. 1897.

To this species belongs the specimen collected by Sheldon at Fergus Falls, Otter Tail county, August, 1892, and referred by him to *Potentilla Nicolletii*. Another specimen, also collected by Sheldon, and determined as *P. Nicolletii*, was obtained at Silver Lake, Otter Tail county, September, 1892.

Potentilla Monspeliensis L. Sp. Pl. 499. 1753.

A specimen of this was collected at Pelican Lake, Otter Tail county, August, 1892, by Sheldon, but referred to *Potentilla Nicolletii*, in Minn. Bot. Stud. 1: 16.

Potentilla Nicolletii (WATS.) SHELDON, Minn. Bot. Stud. **1**: 16. 1894.

Potentilla supina var. *Nicolletii* WATS. Proc. Am. Acad. **8**: 553. 1873.

As shown by the two preceding notes, this species does not occur in Minnesota, for the specimens upon which Mr. Sheldon raised the variety to specific rank, belong to another species, or rather to two species.

Potentilla pentandra ENGELM.: T. & G. Fl. N. A. **1**: 447. 1840.

Not previously reported from Minnesota. Collected at Jordan, Scott county, June, 1891, by C. A. Ballard, no 252. In the Metaspermæ of the Minnesota Valley, this specimen is referred to *Potentilla Canadensis*, a species which it does not at all resemble.

Malus Ioensis (WOOD) BRITTON, Ill. Fl. **2**: 235. 1897.

Pyrus coronaria var. *Ioensis* WOOD, Class Book, 333. 1860.

Pyrus Ioensis BAILEY, Am. Gard. **12**: 473. 1891.

In the Metaspermæ of the Minnesota Valley this species is included under "*Pirus coronaria*," and the following specimens cited there belong to it, and not to *Malus coronaria:* Ballard, 345, Helena, Scott County; Sheldon, 659, Waseca; Sandberg, Red Wing. Sheldon's 322, Smith's Mills, Blue Earth county, may belong here, but the specimen is so mutilated and imperfect that accurate determination from it alone is not possible.

Geranium Bicknellii BRITTON, Bull. Torr. Bot. Club, **24**: 92. 1897.

Apparently common in Minnesota, as evinced by the following collections: J. H. Sandberg, Taylor's Falls, Two Harbors, Red Wing; C. L. Herrick, Minneapolis, St. Louis river; F. F. Wood, Pike Lake; L. H. Bailey, Vermilion Lake, no. 199; T. S. Roberts, Duluth; C. A. Ballard, Prior's Lake, Cleary's Lake, Scott county; B. C. Taylor, Alexandria, Taylor's Falls; Otto Lugger, Tower; E. P. Sheldon, Milaca, Mille Lac Reservation, Nichols. It has heretofore been confused with *Geranium Carolinianum*, but that species does not seem to have been collected in Minnesota, as no specimens from the State are found in the herbarium of the University.

Lechea stricta LEGGETT; Britton, Bull. Torr. Bot. Club, **21**: 251. 1894.

The Illustrated Flora gives the range of this species as "Wisconsin, Illinois, Iowa." It has also been collected at several localities in Minnesota. We have two specimens collected by J. H. Sandberg, one at Sandy Lake, August, 1891, labeled "*Lechea minor*," the other at Centreville, July 30, 1891, labeled "*Lechea Leggettii*." There is also a specimen collected at Zumbrota, August, 1892, by C. A. Ballard, labelled "*Lechea Leggettii*," and one collected by Miss Jennie E. Campbell, at Rockville, July, 1896. E. P. Sheldon also collected it at St. Croix Falls, Wisconsin, September, 1892.

The type of this species was presumably collected by Mr. M. S. Bebb, as we have a specimen from his collection, with the record: "*Lechea stricta*, Leggett ms. . . . Fountaindale, Winnebago County, Illinois, 1879." By referring to the Botanical Gazette, **15**: 308. 1890, I find that the species was reported from Minnesota, previous to its publication, by E. J. Hill, who says: "The only *Lechea* seen was one called by Mr. W. H. Leggett, who has given special attention to these plants, *L. minor* Lam. var *stricta*. It grows on sandy hills, especially those thinly covered with *Pinus Banksiana* and *P. resinosa*, where the ground is not too much shaded, and on rocky hills and ledges with a thin covering of soil, on top of which, Jasper Peak, the highest point in the vicinity of Tower, I find it common."

V. NEW AND INTERESTING SPECIES FROM NEW MEXICO.

A. A. Heller.

Allionia diffusa n. sp.

Stems terete, two or three from a perennial rootstalk, diffusely branched from the base, 20 to 30 cm. in length, whitened and glabrous below, the middle part usually marked with several lines of short, curved hairs, the branches immediately below the inflorescence, as well as the inflorescence itself, covered with spreading, glandular hairs; leaves sessile, lanceolate-linear, slightly narrowed at the base, the lowest 5 to 6 cm. long, the upper ones about half that length, all acute, the upper face provided with a grayish margin, midvein prominent; involucres clustered at the ends of the branches, mature ones about 7 mm. across, their lobes triangular-lanceolate, acutish, between 2 and 3 mm. long; perianth pale rose color, 6 mm. long, its lobes broadly obovate; stamens three, these, as well as the style, exserted.

The type is our no. 3740, collected June 21, 1897, on dry, gravelly hills, ten miles west of Santa Fé, altitude 6000 feet. The diffuse habit of the plant cannot always be well shown in dried specimens, but it is quite marked in the living state, the lower branches being almost procumbent. This species is, perhaps, plentiful in the vicinity of the place where it was first found, but as only one trip was made to that place after it came into bloom, only a few specimens were collected.

Pedicularis fluviatilis n. sp.

Stems several from a perennial root, erect, 15 to 20 cm. high, lanate pubescent, especially above, leafy, or the upper part somewhat naked; leaves alternate, rather distant, dark green, mature ones 5 to 6 cm. long, 1 cm. wide, linear-oblong in outline, acute or acutish, deeply pinnately parted, the lobes of almost uniform width, and lobed or serrate with spreading teeth; spikes leafy bracteate, dense, 4 to 6 cm. long, and almost as broad; calyx 1 cm. long, obliquely cleft to the base on the lower side, the upper side notched with a shallow rounded sinus; corolla lemon yellow or faintly purple tinged, slightly over 2 cm. in length, 6 mm. wide, summit of the galea incurved, the tip provided with two cusps.

The type is our no. 3639, collected June 2, 1897, in a meadow nine miles east of Santa Fé, altitude 8000 feet. The name *fluviatilis* is not very appropriate, but as specimens have been distributed under this name, I consider it better policy to describe it under the name it has borne, rather than cause confusion by assigning another more appropriate one. The specimens were growing in a grassy meadow, on the banks of the Santa Fé creek, opposite "Monument Rock." For some months of the year this meadow is overflowed by water from an irrigating ditch, so that then the plants are actually growing in water, as indicated by the name. This species seems to be closely related to the common eastern *P. Canadensis*.

Pentstemon caudatus n. sp.

Glabrous throughout; stems herbaceous, rather stout and fleshy, simple, erect, 25 to 30 cm. high, pruinose, leafy throughout; leaves all sessile, more or less clasping, pruinose, rather fleshy, margined with a narrow pale line, the lower ones spatulate-oblong, or oblong-lanceolate, moderately acute, 4 to 7 cm. long, 5 mm. to 1 cm. wide, gradually becoming longer and broader until the inflorescence is reached, where they are broadly ovate-lanceolate, with long and narrow tips; beginning with the inflorescence they become gradually shorter, but still retain the broad base, until near the very end of the stalk, where they are reduced to lanceolate bracts: flowers pale violet or pinkish, numerous in thyrsiform close clusters in the axes of the leaves, occupying from one-half to three-fourths of the length of the stem: calyx about 5 mm. long, its lobes lanceolate, or ovate-lanceolate, long-pointed, scarious margined, broadly so near the base; corolla slightly over 2 cm. in length, the tube gradually dilated into the funnelform throat, the orbicular-obovate lobes nearly equal, about 7 mm. long, spreading; sterile filament bearded in the upper half on one side, the tip somewhat dilated and curled; anthers dehiscent from base to apex, puberulous at line of dehiscence.

The type is our no. 3580, collected May 26, 1897, at Barranca, Taos county, altitude 6900 feet. It is very abundant in open grassy, sandy soil, about Barranca station, growing in large patches. This species is likely to occur in Colorado also, as it occurs on the plateau which runs up into Colorado between the two mountain ranges, and specimens of it will probably be found in herbaria under the name of *P. acuminatis* Dougl., which northwestern species seems to be a convenient depository for anything which at all remotely resembles the original.

Senecio Sanguisorbæ DC. Prodr. **6**: 427. 1837.

Specimens referable to this species were collected in Santa Fé Cañon, about twelve miles from Santa Fé. They were growing in wet ground along the stream, at a place well within the woods. Although numerous plants were seen, only a few specimens were obtained, as it was just coming into bloom and that part of the Cañon was not again visited. To the best of my knowledge, the species has not hitherto been recorded within the borders of the United States. No. 3820.

Sitilias Rothrockii (A. Gray) Greene, Pittonia, **2**: 180. 1891.
Pyrrhopappus Rothrockii A. Gray, Proc. Am. Acad. **11**: 80. 1876.

In our distribution of New Mexican plants of 1897, this species was erroneously determined as "*Sitilias multicaulis* (DC.) Greene." It was collected in a meadow along the Rio Grande river opposite the Indian Pueblo of San Juan, no. 3758. The specimens were obtained either in damp ground, or sometimes actually in water in swampy places. In some of the specimens the leaves are entire, or the lower ones only slightly toothed, while in others the lower ones are conspicuously pinnatifid. The original came from "Fisch's Ranch, in southern Arizona, at 5000 feet altitude." Rothrock, 699.

The type-specimens are deposited in the herbarium of the University of Minnesota.

VI. SOME MUSCI OF THE INTERNATIONAL BOUNDARY.

John M. Holzinger.

The mosses listed below were personally collected during the summer of 1897 in northeastern Minnesota along the Dawson canoe-route between Ely and Grand Portage. The route includes the following lakes: Fall, Basswood, Newton, Sucker, Carp, Melon, Seed, Knife, Otter-track, Saganaga, Granite, Gunflint, North, South, Rose, Rove, Mountain, Moose, North-Fowl, South-Fowl and Superior.

Acknowledgements and thanks are due to the following persons for assistance: To M. Jules Cardot for determination of Fontinalaceæ, to Dr. R. True for determination of Dicrana, to Mr. A. J. Grout for determination and correction of the Eurhynchia, Brachythecia and Pylaisiellæ, to Mrs. E. G. Britton for determination of Orthotricha, to Dr. G. N. Best for determination and verification of Leskeæ, Thuidia, Myurellæ and Anomodonta and some other Hypnaceæ, and to Dr. C. Warnstorf for determination of the Sphagna.

A further list, including additional species, may be expected to follow this at a later date.

1. **Sphagnum acutifolium** Ehrh.
   On the point of land at the base of Kawasatchong falls, shore of Fall lake, at Camp 1 (June 8–10, 1897).

2. **Sphagnum fuscum** Klinggr.
   Near Port Arthur, Canada (June 18, 1897).

3. **Sphagnum girgensohnii** Russ.
   On the point of land at the foot of Kawasatchong falls, shore of Fall lake (June 8–10, 1897).

4. **Sphagnum medium** Limpr.
   At the farther end of the portage around Pipestone rapids, between Newton and Basswood lakes (June 11, 1897).

5. **Sphagnum recurvum parvifolium** SONDTN.
With *Sphagnum medium*.

6. **Sphagnum teres squarrosulum** (LESQ.) WARNST.
At the farther end of the portage around Pipestone rapids, between Newton and Basswood lakes (June 11, 1897).

7. **Sphagnum squarrosum** PERS.
On the trail between Eve lake and fall, near the base of Kawasatchong falls (June 8–10, 1897).

8. **Sphagnum wulfianum** GIRG.
Same locality as *S. squarrosum*.

9. **Rhabdoweisia denticulata** B. S.
At the lower end of Pipestone rapids from Newton lake to Basswood lake (June 10, 11, 1897).
On a small point of land at the base of the United States peninsula, shore of Basswood lake (June 11, 1897).
On Safety island, Lake Saganaga (June 16, 1897).

10. **Cynodontium polycarpum** B. S.
On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).
At the farther end of Pipestone rapids, shore of Basswood lake near the portage (June 10, 11, 1897).
On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake, at Camp 4 (June 12, 13, 1897).

11. **Dicranum palustre** LA PYL (**D. boryeani** DE NOT).
On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake, at Camp 4 (June 12, 13, 1897).
On a small island in Lake Saganaga, called by our party Safety island, close by South island, at Camp 8 (June 16, 1897).
On the portage from Mountain lake to Moose lake (June 20, 1897).

12. **Dicranum palustre alatum** BARNES.
On Safety island, in Lake Saganaga. With the species (June 16, 1897).

13. **Dicranum drummondii** C. MÜLL.
On the point of land at the base of Kawasatchong falls, shore of Fall lake, at Camp 1 (June 8–10, 1897).

At the lower end of Pipestone rapids, on Basswood Lake, near Camp 2 (June 10, 11, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake, at Camp 4 (June 21, 13, 1897).

On Safety island, Lake Saganaga, at Camp 8 (June 16, 1897).

On the portage from Mountain lake to Moose lake (June 20, 1897).

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

14. **Dicranum flagellare** HEDW.

On the way from Ely to Winton, shore of Fall lake (June 8, 1897).

On the point of land at the base of Kawasatchong falls, shore of Fall lake, at Camp 1 (June 8–10, 1897).

At the lower end of Pipestone rapids, on Basswood lake, near Camp 2 (June 10, 11, 1897).

On Safety island, Lake Saganaga, at Camp 8 (June 16, 1897).

On the portage from North lake to South lake, the divide between the waters of Hudson Bay and Lake Superior (June 20, 1897).

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

15. **Dicranum fuscescens** TURN.

At the lower end of Pipestone rapids, on Basswood lake, near Camp 2 (June 10, 11, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake, at Camp 4 (June 12, 13, 1897).

At the south end of Gunflint lake, at Camp 10 (June 20, 1897).

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

16. **Dicranum longifolium** HEDW.

At the lower end of Pipestone rapids, on Basswood lake, near Camp 2 (June 10, 11, 1897).

On a small point of land at the base of the United States peninsula, Basswood lake (June 11, 1897).

On Basswood lake, at the farther end of the portage across the United States peninsula (June 12, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake, at Camp 4 (June 12, 13, 1897).

On Safety island, Lake Saganaga, at Camp 8 (June 16, 1897).

On the portage from North lake to South lake (June 20, 1897).

On the portage from Mountain lake to Moose lake (June 21, 1897).

17. **Dicranum montanum** HEDW.

On the point of land at the base of Kawastachong falls, shore of Fall lake, at Camp 1 (June 8, 9, 10, 1897).

At the lower end of Pipestone rapids, on Basswood lake, near Camp 2 (June 10, 11, 1897).

At the farther end of the portage across the United States peninsula, on Basswood lake (June 12, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake, at Camp 4 (June 12, 13, 1897).

On Safety island, Lake Saganaga (June 16, 1897).

At the east end of Gunflint lake (June 20, 1897).

18. **Dicranum scoparium** HEDW.

On the point of land at the base of Kawasatchong falls, on the shore of Fall lake (June 8–10, 1897).

19. **Dicranum undulatum** EHRB.

On the point of land at the base of Kawasatchong falls, shore of Fall lake (June 8–10, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake, at Camp 4 (June 12, 13, 1897).

On the east end of Gunflint lake, at Camp 10 (June 20, 1897).

On the portage from North lake to South lake, the divide between Hudson Bay and Lake Superior (June 20, 1897).

20. **Dicranum viride** B. S.

Along the road from Ely to Fall lake (June 8, 1897).

On the point of land at the base of Kawasatchong falls, shore of Fall lake, at Camp 1 (June 8–10, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake, Camp 4 (June 12, 13, 1897).

21. **Fissidens incurvus** Schw.

On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

22. **Fissidens osmundoides** Hedw.

Locality same as last.

23. **Leucobryum glaucum** Sch.

Near Camp 2, at the lower end of Pipestone rapids, on Basswood lake (June 10, 11, 1897).

24. **Ceratodon purpureus** Brid.

On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

At the farther end of the portage around Pipestone rapids, shore of Basswood lake (June 10, 11, 1897).

Along the portage from Mountain lake to Moose lake (June 20, 1897).

25. **Distichium capillaceum** B. S.

At the base of Kawasatchong falls, shore of Fall lake, Camp 1 (June 8–10, 1897).

At the base of the United States peninsula, basswood lake (June 11, 1897).

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

26. **Barbula ruralis** Hedw.

At the farther end of the portage across the United States peninsula, shore of Basswood lake (June 12, 1897).

27. **Barbula tortuosa** W. and M.

On the point of land at the base of Kawasatchong falls, shore of Fall lake near Camp 1 (June 8–10, 1897).

On Grand Portage island, north shore Lake Superior (June 23, 1897).

28. **Grimmia apocarpa** Hedw.

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake, Camp 4 (June 12, 13, 1897).

29. **Hedwigia ciliata** Ehrh.

On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

On a point of land, at the base of the United States peninsula, shore of Basswood lake (June 11, 1897).

On Safety island, Lake Saganaga (June 16, 1897).

On the portage from South-Fowl lake to Pigeon river (June 21, 1897).

30. **Amphoridium lapponicum** Sch.

On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

31. **Ulota crispa** Brid.

In the woods along the road from Ely to Winton, on Fall lake (June 8, 1897).

32. **Ulota curvifolia** Brid.

On a small point of land at the base of the United States peninsula (June 11, 1897).

33. **Ulota hutchinsiae** Sch.

On Safety island, in Lake Saganaga (June 16, 1897).

34. **Orthotrichum speciosum** Nees.

On the point of land at the base of Kawasatchong falls, shore of Fall lake, near camp 1 (June 8–10, 1897).

Note: This plant agrees in appearance with plants from Idaho and Washington, except that the leaves are only slightly papillose, the papillæ being mostly low and simple, exactly as figured for *O. elegans* Schwaegr., in Husnot, Musc. Gall. Another point of departure is the smooth or nearly smooth capsule. In these two points it seems to approach *O. elegans*. Yet the disposition of the cilia of the peristome is not as described in this species, but as in *O. speciosum*. The plant seems therefore to stand intermediate between *O. speciosum* and *O. elegans*. And in that case Schwägrichen's species is rather *Orthotrichum speciosum elegans*.

35. **Orthotrichum speciosum roellii** Vent.

On trees along the road from Ely to Winton, Fall lake. (June 8, 1897).

36. **Encalypta ciliata** Hedw.

On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

37. **Teraphis pellucida** Hedw.

On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

On a small point of land at the base of United States peinsula, shore of Basswood lake (June 11, 1897).

At the lower end of the portage around Pipestone rapids, shore of Basswood lake (June 10, 11, 1897).

On Safety island, Lake Saganaga (June 16, 1897).

On the portage from South lake to Rat lake (June 20, 1897).

38. **Funaria hygrometrica** Hedw.

On the portage from North lake to South lake, the divide between Hudson Bay and Lake Superior (June 20, 1897).

39. **Bartramia oederi** Schw.

Along the road from Ely to Winton, shore of Fall lake (June 8, 1897).

On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

40. **Bartramia pomiformis** Hedw.

On the lower end of the portage around Pipestone rapids, shore of Basswood lake, near Camp 2 (June 10, 11, 1897).

On a small point of land, at the base of the United States peninsula, Basswood lake (June 11, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake (June 12, 13, 1897).

On Safety island, Lake Saganaga (June 16, 1897).

Near Gunflint station (June, 1897).

On the portage from Mountain lake to Moose lake (June 21, 1897).

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

41. **Leptobryum pyriforme** Sch.

On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

42. **Webera nutans** Hedw.

Same station as the last.

43. **Mnium cuspidatum** HEDW.
Same station as the last.

44. **Mnium punctatum** HEDW.
On the road from Ely to Fall lake (June 8, 1897).
At Camp 1, Fall lake (June 8–10, 1897).

45. **Mnium serratum** BRID.
On a small point of land at the base of the United States peninsula, shore of Basswood lake (June 11, 1897).
On Safety island, Lake Saganaga (June 16, 1897).

46. **Timmia bavarica** HESSL. var **cucullata** (MICHX.).
On Grand Portage island, north shore of Lake Superior (June 23, 1897).

47. **Atrichum undulatum** P. B.
On the point of land at the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

48. **Pogonatum alpinum** ROELL.
On Grand Portage island, north shore of Lake Superior (June 23, 1897).

49. **Polytrichum commune** L.
Same station as the last.

50. **Polytrichum juniperinum** WILLD.
On the point of land at the base of Kawasatchong lake, shore of Fall lake, near Camp 1 (June 8–10, 1897).

51. **Polytrichum piliferum** SCHREB.
On the prairie portage, shore of Basswood lake, near the rapids from Sucker lake (June 12, 13, 1897).

52. **Fontinalis antipyretica** LINN.
In the river crossing the Grand portage about four miles north of Grand Portage village. Abundant (June 21, 1897).

53. **Fontinalis duriaei** SCH.
On submerged rocks at the base of Kawasatchong falls near Camp 1 (June 8–10, 1897).

54. **Fontinalis holzingeri** CARDOT. sp. nova in litt.
At the second falls of Granite river ascending from Lake Saganaga (June 17, 1897).
"Du groupe Heterophyllæ, voisine du *F. missourica* Card., sed foliis rigidioribus, reti firmo, cellulis longi-

oribus, haud vel vix flexuosis, valde chlorophyllosis, parietibus firmis, distincta."

55. **Fontinalis hypnoides** Hartm. "forma foliis apice saepe denticulata."

In the stream flowing from North lake into Little Gunflint lake. Abundant at the lower end of the stream (June 20, 1897).

56. **Dichelyma pallescens** B. S.

At the base of alder trunks growing along the bank of Fall lake, near Camp 1 (June 8–10, 1897).

57. **Neckera oligocarpa** B. S.

Near Camp 1 at the base of Kawasatchong falls, shore of Fall lake (June 8–10, 1897).

On a small point of land near the base of the United States peninsula, Basswood lake (June 11, 1897).

At the farther end of the portage across the United States peninsula, Basswood lake (June 12, 1897).

On Safety island, Lake Saganaga (June 16, 1897).

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

58. **Neckera pennata** Hedw.

On trees along the road from Ely to Winton, on Fall lake (June 8, 1897).

Near Camp 1, on Fall lake (June 10–12, 1897).

On the Prairie Portage, shore of Basswood lake, near the rapids from Sucker lake (June 12, 13, 1897).

59. **Homalia trichomanoides jamesii** (Schimp.).

Near Camp 1, at the base of Kawasatchong falls, shore of Fall lake (June 8–10, 1897).

On the portage from Fall lake to Newton lake (June 10, 11, 1897).

On a small point of land at the base of the United States peninsula, Basswood lake (June 11, 1897).

Note: This plant has leaves varying strongly toward the typical European form of the species.

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

Note: I have carefully studied the plants collected; have compared them with Professor Macoun's Canadian specimens sent out under No. 242; also with the *Ho-*

malia collected by Professor James, near Franconia, N. H., named *H. jamesii* Schimp., and probably typical material of Schimper's species, also with *H. trichomanoides* from Denmark, collected by Dr. J. Hensen, near Hvalsö, in 1883; and I fail to find a single good reason for separating our American forms of *Homalia* with serrate leaves from the European *Homalia trichomanoides* as a distinct species. Not a single constant character can be established for our plant. I have made micrometer measurements of the leaf cells of all the specimens examined, and I find them essentially of the same size in the same part of the leaf in all specimens. The American specimens that are fertile show not the slightest difference from European specimens either in perichætial leaves or in perforation of the segments of the peristome along the keel. The only point of difference is the, on the whole, more obtuse apex of the leaves in our American forms. But it cannot fail to attract the attention of the student, especially when he reviews a large number of forms in different collections, that while in our American forms the apex is on the whole more rounded, some leaves may be found on every plant which have an apiculate apex. Also the European plants studied show some leaves more rounded at the apex than others. As for the description of the European plant, by European authors themselves, let me cite first from Muscineés de la France by M. l'Abbé Boulay (1884), p. 150. "Féuilles largement oblongue-elliptiques, convexes-cultriformes par le bord superieur, un peu repliées en dessus par l'inflexion du bord inferieur, brevement apiculées, très finement denticulées sur tout le contour (dont plus grandes et plus rapprochées ver le sommet; long. 2, larg. 1 mm. * * * * * cellules moyennes 8–10 fois aussi l. q. l.; vers les bords et au sommet, elles sont courtes, rhomboidales; * * * * * lanieres du peristome interne linéares, plus longues que les dents, peu ou millement ouvertes ver la carene."

In Limpricht's Laubmoose II (1895), p. 715: "Blätter gedrängt, zweizerlig-abstrehend, zuletst abwärts gebogen, flach ausgebreiten, unsymmetrisch, aus herablaufender, etwas verschmälerter Bariszungen-messerförmung, stümpflich, 1.8–2 mm. lang, und 1 mm. breit, am Rande der oberen Blatt hälfte ausgefressen-gezähnt, am Grunde, an einer Seite eingeschlagen * * * Innerer Peristom * * * in der linie ritzenförmig durch brochen."

Now in Macoun's Cat. of Can. Pl., 4 (1892), p. 163, the authors of *Homalia macounii*, say of it: "Very nearly allied to *Homalia trichomanoides;* differs in the leaves being longer, rather lingulate, the lowest basal cells yellow, the perichætial leaves more suddenly narrowed to a very short acumen, the segments of the peristome cleft between the articulations." This is quite all in the line of characterization. Among other localities it is credited to Lake Superior, Drummond's specimens having been collected there.

Both from actual comparison and from the circumstance of locality, the Lake Superior plants collected by me are reasonably referred to the same plants upon which *Homalia macounii* is founded. If this inference is correct then the only valid part of the above statements, which stand in place of description, is the first phrase "very nearly allied to *H. trichomanoides*." The leaf length varies according to European authors themselves. The "rather lingulate" form of outline is ascribed by Limpricht to *Homalia trichomanoides*, when he makes the leaves "zungen-messerförmung," *i. e.*, "lingulate-cultriform." As to the "lowest basal cells yellow, the perichætial leaves more suddenly narrowed to a very short acumen," my own close observations fail to verify these two characters, which, if observed by the authors, must have been purely accidental. And as for "the segments of the peristome cleft between the articulations," this character, judging both the European specimens actually examined, and from the painstaking description of *Homalia trichomanoides* made by European authors themselves, as seen from citations above, is unconditionally conceded to belong to *Homalia trichomanoides* Br. The only tangible difference, the slightly more obtuse leaves it certainly has in common with Dr. James' own specimens of *Homalia jamesii*. If now we turn to Lesq. and James' Manual of Mosses of North America (1884), p. 285, we find not a single positive or new character assigned to *Homalia jamesii*, except leaves "striolate lengthwise when dry." And this point is not borne out by the actual examination of James' own material.

It appears, therefore, that *Homalia jamesii* is too close to *H. trichomanoides*; that *Homalia macounii* is identical with *Homalia jamesii*; that the only difference is found in the more obtuse leaves of our species, which proves to be a variable character, and therefore that it should not stand as a distinct species, hardly deserving the name of a variety. As a variety it must be called:

Homalia trichomanoides jamesii (SCHIMP.).

H. jamesii Schimp. in Syn. ( ), p. 473.
H. macounii in Mac. Cat. (1892), p. 163.

The geographical distribution of this variety of *Homalia trichomanoides*, includes necessarily all the stations cited in Macoun's Catalogue for *H. macounii* with those given for *H. jamesii* in Lesquereux and James' Manual.

60. **Myurella careyana** SULL.

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

61. **Myurella julacea** SCH.

At the base of Kawasatchong falls, shore of Fall lake, near Camp 1 (June 8–10, 1897).

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

62. **Leskea nervosa** MYR.

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake (June 12, 13, 1897).

63. **Leskea polycarpa** EHRH.

At the farther end of the portage across the United States peninsula, shore of Basswood lake (June 12, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake (June 12, 13, 1897).

64. **Leskea polycarpa paludosa** SCH.

On the way from Ely to Winton, shore of Fall lake (June 8, 1897).

Along the shore of Fall lake, near Camp 1 (June 8–10, 1897), abundant.

65. **Anomodon attenuatus** HARTM.

Shore of Fall lake, near Camp 1 (June 8–10, 1897).

On a small point of land, at the base of the United States peninsula, shore of Basswood lake (June 11, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake (June 12, 13, 1897).

66. **Anomodon minor** (P. BEAUV.) FÜRN.

On the shore of Fall lake, base of Kawasatchong falls, near Camp 1 (June 8–10, 1897).

67. **Anomodon rostratus** SCH.

On the shore of Fall lake, base of Kawasatchong falls, near Camp 1 (June 8–10, 1897).

On a small point of land, at the base of the United States peninsula, shore of Basswood lake (June 11, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake (June 12, 13, 1897).

68. **Pylaisia heteromalla** SCH.

On trees along the shore of Fall lake, near Camp 1 (June 8–10, 1897).

On a small point, at the base of the United States peninsula, Basswood lake (June 11, 1897).

69. **Pylaisia polyantha** SCH.

On trees along the shore of Fall lake, near Camp 1 (June 8–10, 1897).

On the Prairie portage, shore of Basswood lake, near the rapids from Sucker lake (June 12, 13, 1897).

70. **Platygyrium repens** SCH.

Shore of Fall lake, near Camp 1. On dead logs (June 8–10, 1897).

71. **Cylindrothecium seductrix** SULLIV.

Same locality as above.

72. **Climacium americanum** BRID.

Same locality as above.

Portage from Mountain lake to Moose lake (June 20, 1897).

73. **Thuidium abietinum** SCH.

Shore of Fall lake, near Camp 1 (June 8–10, 1897).

On the Prairie portage, shore of Basswood lake (June 12, 13, 1897).

On the portage from South-Fowl lake to Pigeon river (June 21, 1897).

On Grand Portage island, north shore of Lake Superior (June 23, 1894).

74. **Thuidium recognitum** LINDB.

Shore of Fall lake, near Camp 1 (June 8–10, 1897).

75. **Thuidium philiberti** LIMPR.

At camp, shore of Fall lake (June 8–10, 1897).

76. **Brachythecium campestre** SCH.

Shore of Fall lake near Camp 1 (June 8–10, 1897).

77. **Brachythecium flexicaule** REN. and CARD.

On the Prairie portage, shore of Basswood lake (June 12, 13, 1897).

78. **Brachythecium oxycladon** (BRID.). Grout.

At the base of the United States peninsula, shore of Basswood lake (June 11, 1897).

On the Prairie portage, shore of Basswood lake (June 12, 13, 1897).

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

This last is pronounced a "slender form" by Mr. Grout.

79. **Brachythecium plumosum** SCH.?

On the Prairie portage, shore of Basswood lake (June 12, 13, 1897).

80. **Brachythecium salebrosum** SCH.

Shore of Fall lake, near Camp 1 (June 8–10, 1897).

81. **Brachythecium starkei** SCH.

At the base of the United States peninsula, shore of Basswood lake (June 11, 1897).

82. **Eurynchium robustum** (ROELL.).

At the base of the United States peninsula, shore of Basswood lake (June 11, 1897).

On Basswood lake, at the farther end of the portage across the United States peninsula (June 12, 1897).

Mr. Grout remarks that these plants vary toward *E. strigosum*; they are probably only large forms of this species.

83. **Eurynchium strigosum** Sch.
Shore of Fall lake, near Camp 1 (June 8–10, 1897).
On the portage from South lake to Rat lake (June 20, 1897).
On the portage from South-Fowl lake to Pigeon river (June 21, 1897).
On Grand Portage island, north shore of Lake Superior June 23, 1897).

84. **Raphidostegium recurvans** L. and J.
Shore of Fall lake, near Camp 1 (June 8–10, 1897).
On the point of land at the base of the United States peninsula, Basswood lake (June 11, 1897).
On Safety island, Lake Saganaga (June 16, 1897).

85. **Plagiothecium denticulatum** Sch.
On the road from Ely to Winton, shore of Fall lake (June 8, 1897).
At Camp 1, shore of Fall lake, near Kawasatchong falls (June 8–10, 1897).

86. **Plagiothecium muhlenbeckii** Sch.
At Camp 1, shore of Fall lake (June 8–10, 1897).

87. **Plagiothecium sylvaticum** Sch.
At Camp 1, shore of Fall lake (June 8–10, 1897).
On Grand Portage island, north shore of Lake Superior (June 23, 1897).

88. **Amblystegium adnatum** L. and J.
At Camp 1, shore of Fall lake (June 8–10, 1897). Det. by *G. N. Best.*

89. **Amblystegium serpens** Sch.
On the portage from Mountain lake to Moose lake (June 20, 1897).

90. **Hypnum chrysophyllum** Brid.
At Camp 1, shore of Fall lake (June 8–10, 1897).

91. **Hypnum cupressiforme ericetorum** B. S.
At Camp 1, shore of Fall lake (June 8–10, 1897).
At the lower end of Pipestone rapids, on Basswood lake (June 10, 11, 1897).

92. **Hypnum crista-castrensis** L.

On the road from Ely to Winton, on Fall lake (June 8, 1897).

At Camp 1, on Fall lake (June 8–10, 1897).

At the lower end of Pipestone rapids, on Basswood lake (June 10, 11, 1897).

At the base of the United States peninsula, Basswood lake (June 11, 1897).

Near Camp 3, at the farther end of the portage across the United States peninsula, on Basswood lake (June 12, 1897).

On Prairie portage, shore of Basswood lake (June 12, 13, 1897).

On Safety island, Lake Saganaga (June 16, 1897).

93. **Hypnum filicinum trichodes** BRID.

On Grand Portage island, north shore of Lake Superior (June 23, 1897).

Dr. Best remarks that this approaches the variety *aciculinum* C. M. and K.

94. **Hypnum haldanianum** GREV.

On the road from Ely to Fall lake (June 8, 1897).

At Camp 1, on Fall lake, near Kawasatchong falls (June 8–10, 1897).

At the lower end of the Pipestone rapids, on Basswood lake (June 10, 11, 1897).

At the base of the United States peninsula, on Basswood lake (June 11, 1897).

On the portage from South lake to Rat lake (June 20, 1897).

95. **Hypnum hispidulum** BRID.

On the road from Ely to Fall lake (June 8, 1897).

At Camp 1, on Fall lake (June 8–10, 1897).

96. **Hypnum reptile** RICH.

At Camp 1, on Fall lake (June 8–10, 1897.)

At a small point of land at the base of the United States peninsula, Basswood lake (June 11, 1897).

97. **Hypnum schreberi** WILLD.

At Camp 1, on Fall lake (June 8–10, 1897).

At the lower end of the Pipestone rapids, on Basswood lake, near Camp 2 (June 10, 11, 1897).

At the base of the United States peninsula, Basswood lake (June 11, 1897).
At the farther end of the portage across the United States peninsula, Basswood lake (June 12, 1897).
On Safety island, Lake Saganaga (June 16, 1897).
At the east end of Gunflint lake (June 20, 1897).
On Grand Portage island, north shore of Lake Superior (June 23, 1897).

98. **Hypnum uncinatum** Hedw.
On the road from Ely to Fall lake (June 8, 1897).
On the portage across the divide (June 20, 1897).

99. **Holocomium splendens** Sch.
At Camp 1, shore of Fall lake (June 8–10, 1897).
At the base of the United States peninsula, Basswood lake (June 11, 1897).
On the Prairie portage, shore of Basswood lake (June 12, 13, 1897).
On Safety island, Lake Saganaga (June 16, 1897).
At the east end of Gunflint lake (June 10, 1897).
On Grand Portage island, north shore of Lake Superior (June 23, 1897).

100. **Hylocomium triquetrum** Sch.
On the road from Ely to Fall lake (June 8, 1897).
At Camp 1, shore of Fall lake (June 8–10, 1897).
At the farther end of the portage across the United States peninsula, shore of Basswood lake (June 12, 1897).
On Safety island, Lake Saganaga (June 16, 1897).
At the east end of Gunflint lake (June 20, 1897).
On Grand Portage island, north shore of Lake Superior (June 23, 1897).

VII. THE INFLUENCE OF GASES AND VAPORS UPON THE GROWTH OF PLANTS.

EMIL P. SANDSTEN.

INTRODUCTION.

In recent years considerable attention has been paid by physiologists to the influence of various chemical agents upon the growth of plants, and the results thus far obtained seemed to warrant further investigation along this line. The work heretofore has been confined almost exclusively to the lower plant forms, which are more easily attacked by the difficult technique which is bound up in this kind of inquiries. The recent preliminary results of Johanssen (1) were announced shortly after this work was begun, and it was thought advisable to extend the work to cover the phases of the vegetative period as well as resting seeds, etc. To some extent the writer has had in mind the ultimate application of the reactions obtained in practical gardening though such results are reserved for verification and further trial. The work was done during the fall and winter of 1897 and 1898 in the laboratories of plant physiology in the University of Minnesota under the direction of Dr. D. T. Mac Dougal, to whom the writer is greatly indebted for his valuable advice and kind criticism.

MATERIAL AND METHODS.

The experiments may be conveniently classified as follows:

1. The influence of gases and vapors upon seeds.
2. The influence of gases and vapors upon seedlings.
3. The influence of gases and vapors upon growing shoots.
4. The influence of gases and vapors upon resting bulbs, corms, etc.
5. The influence of gases and vapors upon plants growing in water cultures.

The reagents used were alcohol, ammonia, carbon bisulphide, chloroform, ether, nitrous oxide and oxygen. Small quantities of alcohol (methyl), ammonia (hydrate), carbon bisulphide, ether and chloroform were placed in tubes inside of closed receivers and allowed to vaporize into the air enclosed. The nitrous oxide was the commercial mixture, N_2O 90 parts, N 8.86, O 1.13. In certain experiments the pure gas which had been obtained from ammonium nitrate was used. Commercial oxygen from tanks was used.

As a means of control and test of the actual efficiency of the reagents, leaves of *Philotria* (*Elodea*) and hairs of *Tradescantia*, Tomato, *Begonia*, *Pelargonium* and *Geranium* were mounted in an Engelmann gas chamber and subjected to their action. These tests were carried on at a room temperature of 16 to 23° C., and the results noted below are quite in harmony with those given by previous writers.

Oxygen. The movements of protoplasm are greatly accelerated in an atmosphere of free oxygen for five to seven minutes, after which the movements gradually diminish until they cease entirely. If the living cell is kept under the influence of free oxygen for considerable length of time it dies, but no apparent change in the structure or behavior of the protoplasm could be noticed.

Nitrous oxide (N_2O). This gas has the same general effect on living protoplasm as oxygen with the exception that it is less and does not kill the cell even when exposed for several days in an atmosphere of 90 per cent. nitrous oxide. The duration of active movements varies from three to five minutes (Moeller V.).

Chloroform and Ether. The action of these two reagents are about the same. Aqueous solutions containing 1/20000 part of reagents at first slightly increase the movements of the protoplasm. By increasing the strength of the solution the rapidity of movement was also increased, but the reaction time was very much shortened. Strong solution causes vacuolization and paralyzes the protoplasm.

Ammonia. Weak aqueous solution containing from 1/30000 to 1/20000 parts of ammonia does not seem to modify the activity of the protoplasm when subjected to its action for a short time only. Stronger solution produces vacuolization and slightly accelerates the movements of the protoplasm for a minute or two.

Carbon bisulphide.—The smallest possible quantity that could be introduced arrested all movements.

Alcohol.—Aqueous solutions containing 1/20000 to 1/10000 parts of alcohol had no visible effect upon the protoplasm. A

2 per cent. solution excited rapid irregular movements which stopped inside of two minutes. Vacuolization followed rapidly and the cell was killed inside of ten minutes.

In the experiments where seeds and seedlings were used, *Zea mais*, *Vicia* and *Phaseolus* were employed exclusively. Strawberry plants of the common cultivated kind were used in the experiments with growing shoot and proved well adapted to the work. The strawberry plants were taken from the bed on November 6, 1897, and carefully selected with reference to vigor and equality. Two lots of plants were selected, one lot composed of plants one season old, the other composed of plants two seasons old. The plants were placed in three- and four-inch pots respectively November 9th, and set in a cold frame where they remained until December 9th, when they were taken to the green house and put under the experimental conditions described below.

Dormant bulbs and corms of *Arisæma*, *Narcissus*, Hyacinth, Tulip, *Freesia* and *Crocus* were used for material in the resting stage.

In the experiments with gases in nutrient solution in water culture seedlings of *Zea mais* were used. A large number of seeds were germinated in clean saw-dust and when the seedlings had attained the desired growth the specimens which were to be used in the experiment were carefully selected for vigor and equality. The vessels holding the nutrient solution were glazed earthen jars of two litres capacity. The tops of the earthen jars were fitted with covers made of plaster of paris. Through each cover two holes were drilled, one for the seedlings and a second to admit the necks of inverted flasks of gas. The seedlings were fastened in the openings in the covers by means of a perforated cork after the usual manner in water cultures. The flasks were filled with water, inverted with the necks immersed in the culture fluid and filled with gas by displacement through a bent glass delivery tube.

The following formula was used in making up the nutrient solutions:

Potassium nitrate	25.	gm.
Sodium chloride	12.5	"
Calcium sulphate	12.5	"
Magnesium sulphate	12.5	"
Calcium phosphate	12.5	"
Water	250.	cc.

The solution was diluted to 12500 cc. and from five to eight drops of ferric chloride were introduced in each jar before using.

The bell jars used in enclosing the bulbs and shoots had ground edges and were set upon ground glass plates which had been anointed with a preparation composed of vaseline, tallow and resin, to make the connection absolutely air tight. The temperature was kept as constant as possible.

The pressure of one atmosphere is to be understood where not otherwise stated.

1. The Influence of Gases and Vapors upon the Germination of Seeds.

A. *Gases.* The gases used were nitrous oxide and oxygen. Seeds of *Phaseolus multiflorus* and *Vicia faba* were soaked in water for twenty-four hours and from these were selected ten normal specimens for each experiment. They were then placed on sections of cork, which had previously been soaked in water and introduced into the bell jar under water so as to prevent any air from gaining admittance. Duplicate experiments and duplicate controls were set up. The capacity of bell jars was two litres.

The results obtained with nitrous oxide and oxygen agree with previous experiments in the same line. (Detmer II.) The seed germinated readily in an atmosphere of free oxygen, but failed to do so in an atmosphere of nitrous oxide. The nitrous oxide gas did not kill the seeds, as they afterwards germinated under a bell jar in ordinary air. The N_2O used here was obtained from ammonium nitrate.

B. *Vapors.* Seeds of *Phaseolus multiflorus* and *Vicia faba* were placed under bell jars, 4000 cc. capacity, tightly secured to glass plates. Twelve dry seeds of each kind were placed under each bell jar, together with a small glass vial containing accurately measured quantities of the reagent. The seeds were kept under the bell jars for nine days, when they were taken out and each lot planted separately in four-inch pots. The control experiment was treated exactly in the same way as the others with the exception of the omission of the chemicals. The plants were growing side by side and received the same treatment.

TABLE I.

(KEY.)

I. 1/32000 parts of NOH_4
II. 1/28000 " " "
III. 1/24000 " " "
IV. 1/20000 " " "
(a) *Phaseolus multiflorus.*
(b) *Vicia faba.*
(c) Control of *Phaseolus.*
(d) Control of *Vicia.*

		Per cent. of germination.	Average height 10 days after planting.	Average height 28 days after planting.	Time of blooming.
I.	(a)	100	19 mm.	28 cm.	30 days.
	(b)	90	33 mm.	12.5 cm.	———
	(c)	100	+(a) 51 mm.	30.5 cm.	33 days.
	(d)	100	+(b) 59 mm.	15 cm.	———
II.	(a)	100	18.5 mm.	22.5 cm.	29 days.
	(b)	2	25 mm.	*11.5 cm.	———
	(c)	100	+(a) 51 mm.	30.5 cm.	33 days.
	(d)	100	+(b) 59 mm.	15 cm.	———
III.	(a)	80	30 mm.	27 cm.	31 days.
	(b)	20	51 mm.	11.5 cm.	———
	(c)	100	+(a) 51 mm.	30.5 cm.	33 days.
	(d)	100	+(b) 59 mm.	15 cm.	———
IV.	(a)	0	0	0	———
	(b)	0	0	0	———
	(c)	100	+(a) 51 m.	30.5 cm.	33 days.
	(d)	100	+(b) 59 m.	15 cm.	———

It will be seen that very small quantities of ammonia vapors are not fatal to the germination. In none of the experiments had any of the seeds germinated during the nine days they were under the bell jars, nor had any of the seeds in the control germinated. The odor of ammonia from the seeds treated could readily be detected. It was noticed throughout the experiments that the plants from the treated seeds had a deeper green color than the control. This was especially noticeable in the case of *a* and *b* in series I and II. Nor did it appear that the ammonia vapor had any subsequent bad effect on the plants; on the con-

* One plant only.

trary in series I and II it seems to have hastened the time of the flowering by three to four days. *Vicia faba* is more susceptible to ammonia vapors than *Phaseolus multiflorus*. As in the case of *Phaseolus multiflorus* the leaves were darker than in the control. The measurements given in the table above represent the average growth of shoot of twelve plants.

2. The Influence of Gases and Vapors upon Seedlings.

A. *Gases.*—Nitrous oxide of oxygen and seedling of *Zea mais* and *Phaseolus multiflorus* were employed in these experiments. The seedlings were carefully measured and placed under bell jars while full of water which was displaced by the gases.

The following quantities of gases were used: 400 cc. of nitrous oxide in 2000 cc. of air and an atmosphere of free nitrous oxide; 400 cc. of oxygen in 2000 cc. of air and an atmosphere of free oxygen. These were set up in duplicates and the control was also in duplicate. The results of the experiments showed an increase in growth for seedlings in the two oxygen experiments and also for the nitrous oxide experiment in which 400 cc. in 2000 cc. of air was used. The average increase in the two oxygen experiments and the control for 24 hours was little less than 8 mm. The seedlings in the atmosphere of free oxygen did not average as much as those in the partial atmosphere of oxygen. The average was 5 mm.

The seedlings in the experiments in which 400 cc. in 2000 cc. of air was used showed a slight increase in growth over the control, amounting on an average to 3 mm. The seedlings in an atmosphere of free nitrous oxide did not make any growth, but were alive when taken from the bell jar. The temperature during the time the experiments were running varied from 21–23° C.

B. *Vapors.*—The following chemicals were used: Ether, chloroform, carbon bisulphide, alcohol and ammonia. Seeds of *Zea mais* were germinated in clean saw-dust and when the roots had attained a length of 15 to 20 mm. and the plumule from 10 to 15 mm. a uniform lot was selected for the experiments. The roots and shoots were carefully measured and marked with India ink. The seedlings were next placed under the bell jars of 2000 cc. capacity upon moist saw-dust. The chemicals were accurately measured out and put into small glass bottles containing 100 cc. of water and then placed under the bell jars with the seedlings. The temperature during the experiments varied from 21–23° C. A new quantity of chemical was introduced each time after the seedlings were measured, thus keeping the amount of vapors constant throughout the time the experiments were running. Commercial mixtures of nitrous oxide were used in the above series.

The results are given below in Tables II and III.

TABLE II.

I. .2 cc. of ether in 2000 cc. of air.
II. .2 cc. of chloroform in 2000 cc. of air.
III. .2 cc. of carbon bisulphide in 2000 cc. of air.
IV. .5 cc. alcohol in 2000 cc. of air.
V. Control.

a. Plumule.
b. Root.

Series.	Plants.	Average growth of plumule and root of 10 seedlings in 3 hours.	Average growth of plumule and root of 10 seedlings in 5 hours.	Average growth of plumule and root of 10 seedlings in 24 hours.	Average growth of plumule and root of 10 seedlings in 48 hours.	Total gain or loss over the control.
I.	a.	1.4 mm.	2.15 mm.	9.75 mm.	28.25 mm.	+ 2.45 mm.
	b.	1.75 mm.	3.5 mm.	26 mm.	39.5 mm.	+ 7.5 mm.
II.	a.	1.25 mm.	2.25 mm.	20.3 mm.	32.66 mm.	+ 6.66 mm.
	b.	1.4 mm.	2.5 mm.	28.66 mm.	37.66 mm.	+ 5.66 mm.
III.	a.	1.4 mm.	2.4 mm.	7.25 mm.	14.25 mm.	— 10.55 mm.
	b.	1. mm.	2.88 mm.	6.5 mm.	9. mm.	— 28. mm.
IV.	a.	1.5 mm.	2.75 mm.	14.25 mm.	28.5 mm.	
	b.	2. mm.	2.5 mm.	8.5 mm.	18.25 mm.	-13.75 mm.
V.	a.	1.2 mm.	2.1 mm.	11.8 mm.	25.8 mm.	......
	b.	1.45 mm.	2.5 mm.	16.5 mm.	32. mm.	......

TABLE III.

I. .4 cc. of ether in 2000 cc. of air.
II. .4 cc. of chloroform in 2000 cc. of air
III. .4 cc. of carbon bisulphide in 2000 cc. ot air.
IV. 1. cc. of alcohol in 2000 cc. of air.
V. .2 cc. of ammonia in 2000 cc. of air.
VI. Control.

Series.	Roots.	Average growth of roots of 10 seedlings for 6 hours.	Average growth of roots of 10 seedlings for 24 hours.	Total loss or gain over the control.
I.		1.3 mm.	10. mm.	— 3.1 mm.
II.		1. mm.	7.5 mm.	— 5.6 mm.
III.		.6 mm.	.6 mm.	— 12.5 mm.
IV.		dead.	dead.	
V.		1.3 mm.	13.2 mm.	+ .1 mm.
VI.		1.17 mm.	13.1 mm.	......

From the above tables it will be seen that a very small amount of carbon bisulphide or ammonia vapors is very injurious to young seedlings, while ether, chloroform and alcohol vapors in minute quantities are not injurious when the plant is not subjected to their prolonged action. On the contrary, small amounts of ether and chloroform vapors seem to accelerate growth.

3. THE INFLUENCE OF GASES AND VAPORS UPON GROWING SHOOTS.

A. *Gases.*—Nitrous oxide and oxygen were used in these experiments in the following quantities: 25 per cent., 50 per cent. and 100 per cent. The plants were kept under the bell jars for twenty days.

TABLE IV.

I. 25 per cent. of gas in 4000 cc. of air.
II. 50 per cent. of gas in 4000 cc. of air.
III. One atmosphere of free gas.
IV. Control.

a. Nitrous oxide.
b. Oxygen.

Series.	Chemicals.	Time of first flowers.	Number of flowers.	Number of leaves.	Scale of vigor. Control taken as standard.
I.	a. b.	43 days. 64 days.	3 3	8 7	112 103
II.	a. b.	28 days. no flowers.	17 no flowers.	14 3	125 45
III.	a. b.	42 days. dead.	3	7	102
IV.	a. b.	44 days. 46 days.	1 3	6 7	100 100

In the above table the plants treated with nitrous oxide show a marked increase in vigor and flowering capacity. The leaves were of a dark green color and very large. The leaf petioles were somewhat shortened, giving the plants a stocky appearance. The root systems of the plants treated with nitrous oxide were very strong. All evidence seems to point to the conclusion that the treatment was beneficial to the plants. The oxygen also appeared to be beneficial to the plants when used in quantities not exceeding 50 per cent. In an atmosphere of free oxygen the plants showed no deviation from the normal while in the gas, but upon the removal of the bell jar the plants soon began to show signs of decay. The plants treated with oxygen exhibited a marked elongation of the petioles.

B. *Vapors.*—Ammonia and chloroform were used in these experiments in the following quantities: 1/10000, 1/15000 and 1/40000 parts. The capacity of the bell jars was 7500 cc. The reagents were introduced in an aqueous solution of 100 cc. The plants were kept under the bell jars for 26 hours. Upon examination it was found that the plants which had been subjected to the influence of 1 10000 part of ammonia or chloroform vapors were dead. The leaves had assumed a dirty brown color. The center of the shoot was badly discolored. The appearance of the plants was very similar to that of a frozen plant. The plants which were subjected to 1/15000 part of the reagents were badly effected, the outer leaves were dark brown but the center was not affected. The plants grew but remained weak and straggling throughout the time the experiments were running. The action of the two reagents seemed to be the same, little or no difference could be detected.

The plants which were kept in an atmosphere containing 1/40000 part of the reagents did not appear to be visibly affected when taken from the bell jars. The subsequent influence of the reagents was, however, very marked, especially on the plants in the chloroform experiment. Compared with the control plants at the end of the experiment, February 10, with which they were equal at the start, they showed a great advance.

4. The Influences of Gases and Vapors upon Resting Bulbs.

The bulbs used in these experiments were *Arisæma triphyllum*, *Narcissus*, Hyacinth, *Crocus*, and *Freesia*. The reagents used were oxygen, nitrous oxide, ether, chloroform, carbon bisulphide, ammonia and alcohol. These experiments were started in November and December, months in which bulbs of this kind are very hard to start, since they require a certain period of rest before beginning growth and this period generally extends through the months of October, November and December.

The bulbs were kept under bell jars and the reagents which were in a liquid form were introduced in aqueous solution. Where gases were used in the experiments they were introduced by displacement.

A. *Gases.*—*Narcissus* bulbs were placed under bell jars containing oxygen in the following proportion: 20 per cent., 50 per cent. and 100 per cent. The capacity of the bell jars was 4000 cc.

TABLE V.

I. 20 per cent. of gas.
II. 50 per cent. of gas.
III. 100 per cent. of gas.
IV. Control.

a. Nitrous oxide.
b. Oxygen.

Exposed to gas ten days.

Series.	Reagent.	Average growth when taken from bell jars. mm.	Average growth in 20 days. mm.	Average growth in 30 days. mm.	Average growth in 40 days. mm.	Average growth in 60 days. mm.	Time of first flower. days.	Number of flowers.	Number of flowers from each bulb.
I.	a.	18	70	180.5	260.5	590	44	2	2
	b.	10	60	210.5	330	620	44	4	2
II.	a.	7.5	75	210.5	320.	609	48	1	1
	b.	0	30	230.	440	630	0	0	0
III.	a.	7	50	210.5	330.5	625	38	3	1.5
	b.	0	25	209.5	315	615	44	4	2
IV.	control	29	85	250.5	370.5	640	42	2	2
		18	65	150	280	580	43	3	1.5

It is to be regretted that the root system could not be measured and examined during the experiments without injuring the plants to such an extent as to make the experiment useless. The table does not show anything in favor of the plants treated. The only conclusion that can be drawn is that these gases have no perceptible influence on *Narcissus* bulbs.

Ammonia.—Vapors of this reagent are not injurious to the resting bulb when the amount of vapor present does not exceed one part in 5000 of air. *Arisæma triphyllum*, *Narcissus*, *Crocus*, *Freesia* and Tulip bulbs were exposed to an atmosphere containing one part of ammonia in 5000 of air for ten days without injuring the growing qualities of the bulb.

Chloroform.—Vapors of chloroform seem to be very injurious to resting bulbs. The following quantities of the reagent were used: 1/1000, 1/5000 and 1/10000 part in air and in all three cases the bulbs were killed. The bulbs used were of the same kind as in the experiments with ammonia. The bulb decayed invariably from the shoot area toward the center of the bulbs and never from the root area. The outer portion of the bulb looked perfectly natural. The growing point of the shoot was killed in every case. These results are of but little value since the temperature of the plant house fell to 5° C. during one night.

Alcohol.—This reagent seemed to arrest growth. Experiments were set up containing 1/1000 and 1/500 parts of alcohol in 4000 cc. of air. The bulbs were kept under the bell jars for 10 days and when taken out and potted they were perfectly natural. The root areas had begun to swell. No discoloration was noticeable.

TABLE VI.

I. 1/1000 part alcohol in 4000 of air.
II. 1/500 part of alcohol in 4000 of air.
III. Control.

	Growth in mm. when taken from bell jar.	Average growth in 20 days. mm.	Average growth in 30 days. mm.	Average growth in 40 days. mm.	Average growth in 65 days. mm.	Time of first flower.	Number of flowers.
I.	0	25	125	300	660	0	0
II.	0	0	13	20	31	0	0
III.	0	38	175	310	650	50	2

The above table shows a peculiarly interesting result. In the experiment where 1/1000 part of alcohol was used no ill effect on the plants could be detected. The result is more striking in the experiment where 1/500 part of the alcohol was used. The bulbs remained almost stationary and up to February 19, or 100 days from the time the bulbs were placed under the bell jars, the total growth was only 50 mm. Upon an examination it was found that the root system was perfectly natural and well developed, completely filling the four-inch pots into which the bulbs were growing. In dissecting the bulbs the floral structures were found to be very much dwarfed but the bud scales were well developed. The scapes or flower stems were greatly reduced, being only from 5 to 18 mm. in length. The bulbs which were treated with 1/1000 part alcohol showed the same dwarfed condition of the floral organs.

Bulbs of *Arisæma triphyllum*, *Crocus* and Tulip were treated with the various reagents, but no satisfactory result was obtained. All the *Crocus* bulbs died from some unknown cause or causes. The *Arisæma* bulbs were undoubtedly affected by the change in temperature whieh occurred on the morning of November 23, and to which reference has previously been made.

5. The Influence of Gases upon Growth of Plants Grown in Nutrient Solution of Water Culture.

A. *Land plants grown in nutrient solution.* Seedlings of *Zea mais* were used in these experiments and the method described in the introduction was observed. The duration of the experiment was limited to eighteen days. The average growth for this period, taken in four separate experiments in which the seedlings were grown in a nutrient solution saturated with commercial nitrous oxide, was 203 mm. for the roots and 209 for the shoots. The control plants grown in nutrient solution without nitrous oxide showed an average growth of 213 mm. for the roots and 165 mm. for the shoots. The result shows a gain in favor of the nitrous oxide in the shoot and a loss for the root, but the result needs verification.

B. *Aquatic plants grown in river water.* Wide bell jars were inverted and filled with about one inch of soil over which a thin layer of clean sand was spread; in this substratum several plants of *Philotria* were planted and the bell jar filled about half full of river water. The water in the bell jars was kept saturated with nitrous oxide by means of inverted bottles which were first filled and inserted under water and this water was displaced by nitrous oxide. The bottles were kept in position by means of iron stands. The bottles were refilled as soon as the gas was exhausted.

TABLE VII.

I. *Philotria* in a saturated solution of N_2O.
II. Control.

	Average growth in 5 days. mm.	Average growth in 10 days. mm.	Average growth in 20 days. mm.	Average growth in 30 days. mm.
I.	8	25	53	68
II.	3	9	18.5	29

The marked results shown in the above table were duplicated in all the experiments set up. The average growth of the *Philotria* branches after 28 days taken in another test from four experiments was 17 mm. and the average growth from the control was 11.5 mm.; showing conclusively that nitrous oxide has a stimulating effect on *Philotria*.

To test further the effect of nitrous oxide on aquatic plants, stems of *Salvinia natans*, having an aggregate of 80 leaves were placed in bell jars set up in the same manner as in the previous experiment and the water kept saturated with gas. The experiments were allowed to run for 40 days, when the number of leaves were counted. The control or checks were set up in exactly the same manner as the tests with the exception of nitrous oxide.

TABLE VIII.

I. *Salvinia* in a saturated solution of N_2O.
II. Control.

		Number of leaves at the beginning of the experiment.	Number of leaves at the close of the experiment.	Total gain in number of leaves in 40 days.
I.	a	80	131	51
	a	80	118	38
	a	80	114	34
	a	80	108	28
II.	a	80	99	19
	a	80	104	24

The result of every experiment showed that growth was accelerated by nitrous oxide.

Ammonia was tried on the same water plants under exactly the same conditions as above. One-tenth of a cc. in 2000 cc. of water, and one-five-hundredth of a cc. in 2000 cc. of water were used, but in both cases both the *Salvinia* and *Philotria* plants died.

Conclusions.

Influence of Gases.

From the foregoing tables and records the following conclusions seem to be warranted:

Nitrous oxide. Seeds of *Phaseolus multiflorus* and *Vicia faba* will not germinate in an atmosphere containing 80% of nitrous oxide. Seedling of *Phaseolus multiflorus* and *Vicia faba* will remain active more than 24 hours in an atmosphere of commercial nitrous oxide, but no growth can take place. Shoots exhibit accelerated growth after being kept in an atmosphere of free N_2O or in an atmosphere where the amount of gas ranges from 25 to 100 per cent. No growth in shoots could be detected during the confinement under the bell jars.

Water plants such as *Salvinia natans* and *Philotria* show increased growth in solutions saturated with N_2O.

Oxygen. Seeds readily germinate in an atmosphere of free oxygen. Seedlings kept in an atmosphere of free oxygen do not grow as rapidly as seedlings in a moist chamber containing ordinary air. Growing shoots kept in an atmosphere containing from 25 to 100 per cent. of free oxygen will remain unaltered as long as 20 days, but on removal slowly perish.

Influence of Vapors.

Ammonia (NOH_4).—Vapors of this reagent when used in quantities not exceeding 1/24000 part are not harmful to the germintion of seeds of *Phaseolus multiflorus.* Seeds exposed for nine days in glass chambers containing from 1/24000 to 1/32000 parts of NOH_4 germinated as freely as the control. The seed of *Vicia faba* is very susceptible to the influence of this reagent and seeds kept in a glass chamber for nine days containing 1/28000 part of NOH_4 failed to germinate. In an atmosphere containing 1/32000 part of NOH_4 90 per cent. of the seed germinated.

Seeds of *Phaseolus multiflorus* and *Vicia faba* kept for nine days in an atmosphere containing 1/20000 of NOH_4 failed to germinate. The growth of young seedlings of *Zea mais* kept in a moist chamber for 48 hours containing 1/20000 part NOH_4 was retarded. Growing shoots are badly affected when kept in an atmosphere containing 1/15000 part of NOH_4. Resting bulbs are not effected by being kept in an atmosphere containing one part of NOH_4 in 5000 of air. *Salvinia natans* and *Philotria* are killed by introducing .1 cc. of NOH_4 to every 2000 cc. of water.

Chloroform and Ether.—These two reagents have a very similar effect upon growth. Seedlings of *Zea mais* kept in a moist chamber containing 1/10000 part of chloroform or ether show a marked acceleration in growth after release. In an atmosphere containing 1/5000 growth is greatly retarded. Resting bulbs and growing shoots are equally susceptible and are killed after being exposed for ten to twenty days in an atmosphere containing 1/10000 part of the reagent.

Carbon bisulphide.—The smallest trace of carbon bisulphide present is injurious to growing plants, although, as G. Hicks (III.) has shown, it is inoperative on resting seeds.

Alcohol has no effect upon the growth of seedlings when used in quantities not exceeding 1/10000. If the larger quantities are used the growth is retarded and the seedlings are killed. Resting bulbs kept in an atmosphere containing 1/1000 to 1/500 parts of alcohol grew, but the floral organs were dwarfed and the buds remained unopened.

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VIII. SEEDLINGS OF CERTAIN WOODY PLANTS.

Francis Ramaley.

The following observations on seedlings of woody plants were made at the University of Minnesota, during the years 1896, 1897 and 1898. The plants were grown from seed either collected by the writer, or obtained from reliable dealers.

Most of the species studied have not hitherto been investigated. The author has, however, re-examined some plants described by former investigators, especially in cases where the printed descriptions were incomplete or without illustrations.

The measurements given are in all cases based on a considerable number of plants examined. It has been found that the exact lower limit of the hypocotyl is not always readily determined, although, generally it is enough larger in diameter than the root to be exactly located. It has seemed best in giving the length of the hypocotyl to measure its full extent rather than simply that part above the ground.

An attempt has been made to note, as far as possible, whether the seed coat is carried up or remains underground and also how much the cotyledons increase in size after appearing above the ground. These points have not generally been noted by students of seedlings.

In most cases the length of time required for germination of the seeds is given. The figures are for the first seedlings. Oftentimes plants will appear every few days for over a month after the first have come up. Unless otherwise stated it is to be understood that the seeds were planted in the following spring after ripening. The plants studied will be considered in the order of Engler and Prantl.

SALICACEÆ.

Populus deltoides Marsh.

The seed of the "cottonwood" ripens in June and should be planted at once. The young plants appear above ground in a week or sooner.

The cotyledons are petiolate, the blade being ovate-oblong, about 5 mm. in length and 4 mm. broad. The petiole is about 3 mm. long. There is but little increase in size as the plant grows older.

The first two leaves are opposite, lanceolate, short-petiolate, of willow-like shape. They are about 10 mm. long before the epicotyl has developed at all and do not afterward increase in size. The hypocotyl is 10–15 mm. long; the epicotyl reaches a length of 8 or 10 mm.

The third and fourth leaves are nearly opposite; later ones are alternate. The later leaves become broader and longer petioled, gradually assuming the deltoid form characteristic of the species.

ULMACEÆ.

Ulmus americana Linn.

The "white elm" is a native of the eastern and central United States. The seeds ripen in early spring and must be sown at once. They germinate in about a week. Often, but not always, the pericarp is carried up by the growing seedling.

The cotyledons are at first obovate, slightly auriculate, 5 mm. long and 2–3 mm. broad. They are indistinctly reticulately veined. They increase but slightly in size and seldom become more than 7 mm. long. They are short-petioled. The hypocotyl is slender, not enlarged at the base, 25–35 mm. long, but in time it may reach a length of 50 mm. The epicotyl is about 10 mm. in length.

The leaves are petiolate, ovate, coarsely serrate, with distinct veining. The first two are opposite, the third and fourth nearly so. Later leaves are alternate.

Ulmus fulva Michx.

The "slippery elm," like the previously described species, ripens its seeds early in the spring. These, when planted at once, germinate in about two weeks. The seedling resembles that of *U. Americana* in all essential respects.

Celtis occidentalis Linn.

This is a fine tree native to the central United States and Canada. It is known as the "hackberry." The seeds germinate in from four to six weeks. The seed coat remains under ground.

The cotyledons are at first 10 mm. long, but by the time the first pair of foliage leaves appear they are 30 mm. in length, 17 mm. in width, ovate, entire, notched at the apex. The epicotyl is 10 mm. in length. The figures here given are substantially correct for all the plants examined by the present writer. Lubbock's * figures for seedlings of this species are about one-half those here given.

The epicotyl is at length 20 mm. long. The first two foliage leaves are opposite, the later ones alternate. Leaves of the first year are not at all conspicuously oblique at base as are those of older plants.

MORACEÆ.

Toxylon pomiferum Raf.

This is the well-known "osage orange" of the south-central United States. The seeds germinate in about one month after planting. The seed coat is often carried up by the cotyledons which are thus prevented from opening till they have increased somewhat in size.

When they first appear the cotyledons are 9 mm. long and 5 mm. broad, obovate-oblong, entire, short-petioled. The hypocotyl is stout, 35–50 mm. long.

The cotyledons grow rapidly in size and by the time the first leaves are well developed have increased to 20 mm. in length and 12 mm. in width. The petiole is distinctly margined and 4 mm. long. The veining of the blade is distinct. The epicotyl is 10–15 mm. long. The first two foliage leaves are opposite, narrowly lanceolate, ovate, entire or nearly so, distinctly veined. The later leaves are alternate, often pointed at the base as well as the apex. The seedling of this plant was studied by Lubbock,† but not figured.

Broussonetia papyrifera (Linn.) Vent.

The seeds of this oriental tree, the "paper mulberry," germinate in about three or four weeks after planting. The seed coat is carried up and often remains attached to one of the cotyledons for a time after they have opened.

The hypocotyl is rather slender, 12–15 mm. long. The

* On Seedlings, **2**: 493. 1892.

† Op. cit. **2**: 498.

cotyledons are oval; when fully open they have a petiole 2 mm. long and blade 8 mm. long and 5 mm. broad, very slightly notched at the apex. When they first emerge from the seed coat the leaves are not over 5 mm. in length.

The first foliage leaves are opposite; they are petiolate, narrowly ovate, serrate, slightly heart-shaped at base and more nearly entire than the later leaves which are alternate, long-petioled, serrate and frequently more or less two- or three-lobed or parted. Usually about the close of the second season the well-known peculiar characteristic leaves make their appearance.

MAGNOLIACEÆ.

Liriodendron tulipifera LINN.

The seeds of the "tulip tree" germinate in from four to six weeks after planting. The wing-like pericarp remains in the soil.

The cotyledons when they first appear are about 7 mm. long and 5 mm. broad, almost sessile, ovate-oblong in shape. Before the first leaf appears each cotyledon has developed a distinct petiole 2 or 3 mm. long, while the blade is about 12 mm. in length.

The foliage leaves are alternate. The first is broadly ovate-oblong, petiolate, emarginate, with entire margin. The second and third resemble the first. The characteristic leaves appear toward the close of the first season or not till the second year. The epicotyl is extremely short, 1–2 mm. long. Succeeding internodes are likewise short.

CALYCANTHACEÆ.

Butneria florida (LINN.) KEARNEY.

This is the familiar "sweet-scented shrub" commonly cultivated in the eastern United States. It is native from Virginia to the Gulf of Mexico. The seeds require a month or more to germinate. The cotyledons are rolled longitudinally about each other in the seed and remain rolled up for two or three days after appearing above ground.

The hypocotyl is stout, 20 mm. long. Cotyledons are thick, dark green, slightly auriculate at base, petiolate, generally somewhat trapezoidal, the apex broadly incurved. They are at first about 12–15 mm. long and 25 mm. broad. Eventually they may become 20 mm. long and 30 mm. broad with petioles 10 mm. in length. In shape they are often quite asymmetrical.

The foliage leaves are opposite, ovate, pointed, entire. The first do not differ materially from the later ones. The epicotyl is about the same length as the hypocotyl.

Butneria fertilis (WALT.) KEARNEY.

The seedling of this plant does not differ in any important respect from that of the species just described.

CAESALPINACEÆ.

Parkinsonia aculeata LINN.

The seeds of this shrub germinate in about two weeks after planting. The seed coat is usually carried up.

When they first appear the cotyledons are 15 mm. long, 8 mm. broad, ovate-elliptical, sessile, very slightly auriculate at base. The hypocotyl is stout, 30–50 mm. in length. The cotyledons increase in size until they are 25 mm. long.

Foliage leaves are alternate; all are pinnate, the first has five pairs, the second six pairs of leaflets. The epicotyl is 9 mm. long when two leaves have appeared.

Cercis canadensis LINN.

This is the well-known "red bud" or "Judas tree" of the central United States. The seeds germinate in about two weeks. The seed coat is usually carried up, holding the cotyledons together until erect. The veins of the cotyledons are distinct even before the cotyledons have separated.

The cotyledons are broadly ovate, at first 6 mm. long and 4 mm. broad, eventually 15 mm. long and 8 mm. broad. The hypocotyl is stout, 10–30 mm. long. This is of interest since the hypocotyl of *C. siliquastrum* WILLD., as described by Lubbock,* is but 5–6 mm. in length.

The epicotyl is 20–30 mm. long. Foliage leaves are all alternate, entire, cordate, long-petioled.

Gleditsia triacanthos LINN.

The "honey locust," as this plant is called, is a familiar tree of the central United States. The seeds germinate in about one

* Op. cit. 1: 465.

month after sowing. The seed coat is sometimes carried above ground, but it as often remains in the soil.

The hypocotyl is stout, 25–30 mm. in length. The cotyledons are sessile, slightly auriculate, oblong, 18 mm. in length and 9 mm. broad. They do not increase greatly in size.

Leaves are alternate and pinnate. The second appears before the first is fully open. The first leaf usually has eight pairs of leaflets, the second has eleven pairs, the third thirteen pairs. When these leaves have developed the hypocotyl is about 50 mm. long, the epicotyl 20–25 mm.

The first leaves are described by Tubeuf * as having ten pairs of leaflets. In the plants examined by the present writer the first leaf had never more than nine pairs of leaflets.

PAPILIONACEÆ.

Amorpha fruticosa Linn.

This is an ornamental shrub indigenous to North America and frequently cultivated. The seeds germinate in about two weeks after planting.

When the cotyledons first appear they are ovate in shape, about 5 mm. long and 2.5 mm. broad. By the time they are fully open they measure 8 mm. in length. The hypocotyl at this time is 25 mm. long, quite slender, gradually thickened below.

The cotyledons attain a length of 12 mm. They are sessile. The epicotyl is 15 mm. in length. Foliage leaves are alternate. The first five or six are simple, broadly ovate, petiolate. After these the leaves are, for a space, pinnately trifoliate. The terminal leaflet is larger and longer stalked than the lateral ones. Later leaves are pinnate with numerous leaflets.

Amorpha nana Nutt.

The seedlings of this shrub resemble those of *A. fruticosa* save that they are much smaller. The hypocotyl does not become more than 8 or 10 mm. in length and the epicotyl is only about 5 mm. long. Cotyledons are 5 mm. long and 3 mm. broad.

Leaves are alternate. The first six to ten are simple. They are broadly orbicular, emarginate, petiolate, with a distinct midvein. As in the former species the later leaves are pinnately compound.

* Samen, Früchte und Keimlinge, 12^mo^. 1891.

The writer is indebted to Mr. D. M. Andrews, of Boulder, Colo., for seedlings of this plant and of *Acer glabrum*.

Robinia pseudacacia Linn.

The "locust tree" is a native of the middle and southeastern United States. The seeds germinate in about two weeks after planting.

Seedlings of this plant were studied by Lubbock * and by Flot † but the fact is not stated by these writers that the cotyledons are at first somewhat narrowly elliptical or obovate and only at a rather late stage become "oblong-oval." The descriptions hitherto published have not been accompanied by satisfactory figures.

RUTACEÆ.

Ptelea trifoliata Linn.

This is the so-called "hop tree" of the central United States. The seeds germinate in from three to four weeks, the seed coat remaining underground. Almost as soon as the cotyledons get above ground they become erect and then separate.

The cotyledons are nearly sessile, elliptical-oblong, entire, 6 mm. long and 3 mm. broad. They grow for some time and become at length 18 mm. long, 7 mm. broad, minutely serrate, short-petiolate, with midvein distinct. The hypocotyl is rather stout, 15–20 mm. long.

The epicotyl is 20–40 mm. long when the first leaf is fully open. It often elongates somewhat after that time. Leaves are alternate. The first foliage leaf is usually simple, ovate, petiolate, with crenulate margin. Sometimes it is trifoliate, sometimes but partially compound; perhaps one of the side leaflets is separate, but not the other. The second leaf is usually trifoliate, sometimes incompletely so. Later leaves are all trifoliate, the terminal leaflet larger than the lateral ones.

A description of this seedling is given by Lubbock ‡ but there is no figure.

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* Op. cit., 1 : 422.

† Flot. Recherches sur la structure comparée de la tige des arbres.—Rev. gen. de Bot. 2 : 20. 1890.

‡ Op. cit. 1 : 322.

SIMARUBACEÆ.

Ailanthus glandulosa Desf.

This well-known tree is a native of eastern Asia. It is, however, grown extensively in this country. The writer's observations on the seedlings differ somewhat from those previously published.*

The seeds, planted in May, germinated in from two to three weeks. The seed coat and wing sometimes remain in the ground but are quite often carried up by the elongation of the hypocotyl before the cotyledons emerge.

The cotyledons are at first about 6 mm. long. By the time they are fully open they have increased somewhat in size and the hypocotyl has attained its full length, viz. about 40 mm. When the first leaves have opened the cotyledons are broadly obovate, petiolate, with the blade 15 mm. long, 11 mm. broad and the petiole 5 mm. long.

The epicotyl is at length 20 mm. long. The first few leaves are trifoliate. Later leaves are pinnate.

ANACARDIACEÆ.

Schinus molle Linn.

This is the so-called "pepper-tree" sometimes planted in California but a native of tropical America. A description of the germination of the seed is given by Lubbock,† whose account in this case, the present writer only desires to supplement.

The cotyledons are remarkable for their great increase in size; beginning with a length of 5 mm. the blade is finally 20–25 mm. long and broad in proportion. The petiole is about 4 mm. in length.

CELASTRACEÆ.

Celastrus scandens Linn.

This is the "climbing bitter-sweet," a common native liana of the United States. It is frequently cultivated. The seeds ripen in the fall. If planted the following spring they usually require a year to germinate.

The cotyledons are thin, reticulately veined, petiolate, oval-oblong in shape. At first they are 10 mm. long and 5 mm.

* Lubbock op. cit. 1: 327.

† Op. cit. 2: 335.

broad, but grow rapidly and become about twice that size. As they grow older they become broader in proportion to the length. The petiole is finally about 5 mm. long. The hypocotyl tapers gradually to the root so that its exact limit is not easily recognized. It reaches a length of 40 or 50 mm.

The epicotyl is about 15 mm. long. Leaves are all alternate. The first leaves are not different from those formed later.

ACERACEÆ.

Acer negundo Linn.

Seeds of the "box-elder" germinate in from one to two weeks after sowing. The large winged pericarp is brought above ground.

The hypocotyl is 25–35 mm. long when the cotyledons first open and does not grow longer. The cotyledons are strap-shaped, sessile, entire, tri-veined; about 30 mm. long and 5 mm. broad.

The epicotyl becomes 5–8 mm. long. Leaves are opposite. The first two are ovate, acute, serrate, petiolate. Later ones are tri-cleft. Usually the sixth or seventh pair and all later ones are pinnately compound.

Acer glabrum Torr.

The seedling of the "Rocky mountain maple" resembles that of *A. negundo*. The hypocotyl is shorter, 20 mm. long, and the cotyledons about 20 mm. long, 5 mm. broad. Leaves are opposite, long-petioled, ovate-cordate, the second pair somewhat lobed. Later leaves are three- or five-lobed, the lobes more or less acute and sharply serrate.

Acer saccharinum Linn.

The seeds of the "soft maple" germinate in about ten days after planting. The first leaves are well developed when the plant appears above ground. The cotyledons remain in the soil for a time enclosed in the pericarp which eventually decays. Sometimes they do not appear above ground * at all.

The hypocotyl is stout, about 20 mm. long. The cotyledons are somewhat fleshy, asymmetrical, short-petioled, bent around

* Winkler. Kleinere morph. Mittheilungen, in Verhandl. d. Bot. Ver. d. Provinz Brandenburg, 18: 99. 1877.

so that both are on the same side of the stem. They are about 16 mm. long and 8 mm. broad.

The epicotyl often becomes greatly elongated, reaching a length of 50–100 mm. Leaves are all opposite, those of the seedling are the same shape as the later leaves.

RHAMNACEÆ.

Berchemia racemosa Sieb. & Zucc.

This plant is a shrub with conspicuously veined leaves. It is a native of Asia. The seeds require two or three weeks to germinate. It is often a number of days before the cotyledons get out of the seed coat which is carried above ground.

When the cotyledons first emerge they are sessile, strap-shaped, 8 mm. long and 1½ mm. broad. They remain about the same size for a time after they are fully open. The hypocotyl is slender, about 15 mm. long.

By the time the first foliage leaves are open the hypocotyl is 15–20 mm. long; the epicotyl 5 mm. in length and the cotyledons 10 or 12 mm. long and 1.5–2 mm. broad. The foliage leaves are ovate, petiolate, conspicuously veined; the first two are opposite or nearly so, all others are alternate.

Rhamnus purshiana DC.

This is a handsome tree of Pacific North America sometimes planted in the eastern United States. The bark is the "Cascara Sagrada" of the drug stores. The seeds require a month or more to germinate.

The cotyledons increase but slightly in size after opening. They are obovate, entire, sessile or nearly so, 7 mm. long and 5 mm. broad. The hypocotyl is 25–30 mm. long.

The epicotyl is slender, 15–20 mm. long. Foliage leaves are ovate, pointed, petiolate, alternate. The first two and the third and fourth are, however, nearly opposite. The margin of the leaf is finely serrate; the veining very prominent.

VITACEÆ.

Vitis cordifolia Michx.

This is one of the commonest wild grapes found in the northern United States. The seeds germinate readily, the cotyledons appearing above ground in about four weeks. Sometimes the seeds do not germinate till the second year.

The cotyledons are ovate, petiolate, veined. When they first appear the blades are about 10 mm. long and 6 mm. broad. They grow to about 18 mm. in length, and a corresponding width before the first leaves appear, after which time they do not increase in size. The petiole is about 8 mm. long. The hypocotyl is stout, from 25–30 mm. long; it does not grow longer.

The leaves are all alternate, ovate-heart-shaped, irregularly dentate, palmately 5-veined. When the first leaf appears the epicotyl is about 8 mm. long. It may eventually reach a length of 10 or 12 mm.

Parthenocissus quinquefolia (Linn.) Planch.

This is the familiar "Virginia creeper," a native of the United States and frequently planted. Seeds germinate in about three weeks.

The hypocotyl is stout, from 20–40 mm. long. The cotyledons are long-petiolate. The blade is cordate, prominently veined, at length 20 mm. long, 20 mm. broad. The petiole is channeled, 20 mm. long. Both hypocotyl and petioles are pink except that part of the hypocotyl which is below ground. The hypocotyl becomes very much thickened toward the end of the season, exhibiting a well-marked "region tigellaire."

The epicotyl is undeveloped, the first leaf arising just above the cotyledons. Leaves are all alternate and quinquefoliate from the beginning. The first do not differ from the later ones.

STERCULIACEÆ.

Sterculia platanifolia Linn.

The seeds of this oriental tree germinate in about a month after planting. A part of the seed coat is often attached to the cotyledons when they first appear above the ground.

The hypocotyl is stout, 40 mm. long at the time the cotyledons open. These are broadly oblong or orbicular, entire, slightly cordate at base, with petioles nearly as long as the blades. The latter are at first about 18 mm. long and 16 mm. broad but become very large, sometimes 40 mm. long and 45 mm. broad. They are palmately five-veined. The midvein forks some distance from the apex.

The epicotyl is about 10 mm. long. Leaves are alternate. The first leaf is broadly heart-shaped, entire, petiolate, palmately five-veined; the midvein runs to the apex of the leaf.

ELÆAGNACEÆ.

Elæagnus umbellata Thunb.

The seeds of this Japanese shrub require about four weeks to germinate. The seed coat is often carried up above ground.

The cotyledons are oblong-ovate, sharply auriculate, short-petiolate. The blades are quite thick. When they first emerge from the seed coat they are 7–8 mm. long but are finally 10 mm. long and 6 mm. broad. The hypocotyl is rather stout, 10–30 mm. long.

The foliage leaves are ovate, entire, petiolate. The first two are opposite or nearly so, later ones are alternate. The epicotyl is short, not usually more than 2 or 3 mm. in length when the first leaves are well developed. It eventually may grow to a length of 4–8 mm.

The seedlings of this plant resemble very much those of *E. angustifolia microcarpa** save that in the latter the petioles of the cotyledons are much longer.

MYRTACEÆ.

Eucalyptus globulus Labill.

This is the well-known "blue gum" tree of Australia. It is planted extensively in California. The seeds germinate in from one to two weeks. The seed coat is often carried up by the cotyledons. These are doubled over each other. One lobe of each is exposed.

The hypocotyl is slender, about 30 mm. long. The cotyledons, when fully opened, are short-petiolate, 3 mm. long and generally twice as broad, two-lobed, the sinus shallow. When first out of the seed coat the cotyledons are about one-half the size here named. No distinct venation was observed, although Lubbock† states that they are tri-nerved.

The epicotyl is about 10 mm. long. The foliage leaves are opposite, lanceolate and entire, those higher on the stem be-

*Lubbock, op. cit. 2 : 465.

†Op. cit. 1 : 530.

coming gradually broader. Higher internodes of the stem are quadrangular.

Eucalyptus citriodora Hook.

The mode of germination and the seedling of the "lemon-scented gum" resemble the species just described. There are some important points, however, to be noted.

The hypocotyl is 20 mm. long and quite slender. The cotyledons are petiolate. The blade is broadly orbicular, entire, indistinctly 3-veined; at length 6–9 mm. broad, 4–7 mm. long, green above, red to purple below. The petiole is 3–4 mm. in length. The cotyledons are persistent for a considerable time; often remaining till ten or more nodes of the stem are developed.

Eucalyptus corymbosa Sm.

This plant, also a native of Australia, is called "blood-wood." Seeds germinate in two or three weeks. The hypocotyl is 20 mm. long and quite slender. The cotyledons are short-petiolate. The blade is reniform, deeply cordate at base, at first 2–3 mm. long and 5–6 mm. broad. It finally grows about twice this size and is indistinctly 3-veined.

CORNACEÆ.

Cornus amomum Mill.

The seeds of the common "dogwood" germinate in two or three weeks after planting, but sometimes not till the following year.

The hypocotyl is rather slender and quite long, usually 50 mm. or more in length. The epicotyl also is greatly elongated, reaching a length of 40 mm. The cotyledons are oblong-elliptical, entire, short-petiolate. At first they are 10 mm. long and 5 mm. broad. The blades become 20 mm. long and 10 mm. broad, the petioles 4 mm. long.

Leaves are all opposite, ovate, acute, petiolate. The first are like the later ones.

Cornus stolonifera Michx.

Seedlings of this plant resemble those of the previous species in all essential respects.

Cornus florida Linn.

Seedlings of the "flowering dogwood" resemble those of *C. amomum*.

STYRACACEÆ.

Mohrodendron carolinum (Linn.) Britt.

Seeds of this plant, the "snow-drop tree," planted in the spring of the year following their ripening lie dormant an entire year before germinating.

The cotyledons are thin, oval-oblong in outline, rather short-petiolate. The blades are at first 20 mm. long and 8 mm. broad. They do not increase much in size. The hypocotyl is stout, from 25–35 mm. long.

The epicotyl is about 20 mm. long. The leaves are all alternate, ovate-acute, serrate, petiolate. Save in size there is no difference between the first and the later leaves.

BIGNONIACEÆ.

Tecoma radicans (Linn.) DC.

This is a woody climber, the "trumpet creeper," indigenous to eastern North America and frequently cultivated. The seeds germinate in about ten days. The large flat wing of the seed is sometimes, though not usually, carried up.

The cotyledons are broadly orbicular and deeply notched at the apex. They are almost sessile. When first above ground they are 5 mm. wide, but when fully open are 9 mm. wide. They do not increase in size after that time. The hypocotyl is 20–30 mm. long, green or pale, sometimes pinkish.

The epicotyl is at first quite short, but lengthens, when the foliage leaves open, to about 15 mm. The first leaves are simple, ovate, dentate, petiolate, distinctly veined. The next leaves are tri-foliate. Leaves at length are pinnately compound.

Catalpa speciosa Warder.

This large tree is a native of the southern United States. Seeds germinate in from one to two weeks. The flat winged seedcoat is sometimes carried up, but more usually remains in the soil.

The cotyledons are face to face. They are dark green, deeply bifid, the lobes more or less obovate, 5–6 mm. long and 3–4 mm. broad. They increase rapidly to nearly twice their original size. The hypocotyl is stout, 30 mm. long.

The epicotyl is 8–12 mm. long. Foliage leaves are opposite, entire, pointed, ovate to cordate, petiolate with distinct veining.

Seedlings of this plant have been previously* described, but without measurements or illustrations.

RUBIACEÆ.

Cephalanthus occidentalis Linn.

The "button bush" is a low shrub indigenous throughout most of North America. The seed germinates in about three weeks. The seed coat remains in the ground.

The cotyledons are ovate, acute, short-petiolate, 3 mm. long and 1 mm. broad when they first appear; at length they become about twice or three times that size. The hypocotyl is slender, 15–30 mm. in length.

When the first foliage leaves are open the epicotyl is from 4–8 mm. long. Leaves are opposite, ovate, acute, entire, long-petioled, distinctly veined.

CAPRIFOLIACEÆ.

Sambucus pubens Michx.

This is the "red-berried elder" of the northern United States. The seeds ripen in June. If sown at once they germinate in about one month. Some of the seeds, however, do not come up until the following spring.

The hypocotyl, which passes gradually into the root, is about 10 or 15 mm. long. The cotyledons are petiolate. When they first appear they are 3 mm. long and 2 mm. broad. The cotyledons become longer petioled and the blades more ovate as they grow older. By the time two pairs of foliage leaves have appeared they are 10–15 mm. in length with petiole 8 mm. long.

The epicotyl is very short as are also the succeeding internodes. Leaves are opposite; the first two pairs cordate, serrate, with petioles as long as the blades. The next leaves are generally trifoliate; later ones are pinnately multifoliate.

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*Lubbock, op. cit. 2 : 335.

General Observations on the Facts Recorded in the Preceding Pages.

Without any attempt at ecological explanations of the phenomena of the growth and development of seedlings such as given by Goebel* a few generalizations may be made from the plants at present examined. Some of the features to which attention is called have been previously discussed by Klebs† and Lubbock‡ so that what follows will not be so much a consideration of such points but rather a classification of the plants studied with regard to their special peculiarities.

A knowledge of the shape and general structure of the cotyledons does not help one to predict the character of the foliage leaves. Sometimes there is a certain resemblance between cotyledons and the first foliage leaves or even the later ones. The resemblance is, however, chiefly in cases where the cotyledons are ovate or oblong. This is a very common form for foliage leaves as well. Thus in *Toxylon pomiferum* and *Cephalanthus occidentalis* the cotyledons and foliage leaves are much alike. That the two kinds of leaves are of the same general shape, may be a mere coincidence and of no great significance.

Where the general shape of cotyledons and first foliage leaves is much the same, the former may have entire margins and the latter be variously toothed or lobed, *e. g.*, *Vitis cordifolia*, *Ptelea trifoliata*. While, as has been said, there is no absolute agreement in the shape of cotyledons in a given genus or family, nevertheless, there are, as is well known, many families in which certain types of cotyledons prevail. The first foliage leaves, however, are more frequently alike, *e. g.*, *Acer* spp.

In cases where leaves of old plants are pinnately compound the first few foliage leaves are often simple, *e. g.*, *Acer negundo*, *Amorpha* spp., *Ptelea trifoliata*, *Schinus molle*, *Robinia pseudacacia*, *Sambucus* spp. In all these cases the transition to the compound form is gradual. Thus in *Ptelea trifoliata* the first leaf is simple, the second leaf usually has but one lateral leaflet. In *Robinia pseudacacia* the second leaf is trifoliate while later leaves are more and more multifoliate.

Occasionally even the first foliage leaf is compound, as in

* Organographie der Pflanzen, 1898.

† Beiträge zur Morph. und Biol. der Keimung. Pfeffer's Untersuchungen aus dem Botan. Inst. zu Tübingen 1: 536. 1885.

‡ Op. cit.

Parthenocissus quinquefolia. In *Ailanthus glandulosa*, however, the first few leaves are merely trifoliate while later ones are pinnate. *Parkinsonia* and *Gleditsia* produce pinnate foliage leaves at once, although the earlier leaves have fewer leaflets than those that come afterward.

If the later-formed leaves are not compound but merely lobed or cleft there may be traced a more or less gradual transition to that shape from the entire or more nearly entire first leaves, *e. g.*, *Broussonetia papyrifera*, *Liriodendron tulipifera.*

In nearly all cases where the first two leaves are opposite and the later ones alternate, it is to be noted that the third and fourth are nearly opposite, the fifth and sixth are closer together on the stem than the fourth and fifth or than the sixth and seventh; *e. g.*, *Rhamnus purshiana*, *Eucalyptus* spp., *Ulmus* spp. In other words, the transition from the opposite to the alternate arrangement is usually gradual.

The cotyledons of many species increase considerably in size after they escape from the seed coat; this is particularly noticeable in *Schinus molle*, *Cercis canadensis*, and some others. In other species there is very little increase in the size of the cotyledons after they first appear, *e. g.*, *Rhamnus purshiana*, *Ailanthus glandulosa.*

Cotyledons of rather remarkable shape were noted in the following species: *Celtis occidentalis*, *Catalpa speciosa*, *Eucalyptus globulus*, *Tecoma radicans*, *Acer negundo*, *Berchemia racemosa*, *Butneria florida* and *fertilis.* The first four named have the cotyledons bifid or variously notched or retuse.

Catalpa and *Tecoma*, both Bignoniaceous plants, have very similar cotyledons. The peculiar asymmetrical cotyledons of *Butneria florida* are reproduced exactly in *B. fertilis.* *Eucalyptus globulus*, on the other hand, does not agree at all, in the shape of its cotyledons, with *E. citriodora* and *E. corymbosa.* These have rotund-orbicular cotyledons. The long, narrow cotyledons of *Acer negundo* are quite different from those of *A. saccharinum.* *Berchemia racemosa* has ligulate cotyledons, while in *Rhamnus purshiana*, the only other plant of the same family investigated, the cotyledons are obovate. The large notched cotyledons of *Celtis occidentalis* do not resemble those of the other Ulmaceæ examined. This, is, however, to be expected from the great difference in the character of the fruit in *Celtis* and *Ulmus.*

From the foregoing it may be concluded that broad generalizations in regard to the shape of cotyledons in plant families, cannot be safely made without a considerable mass of data.

Explanation of Plates.

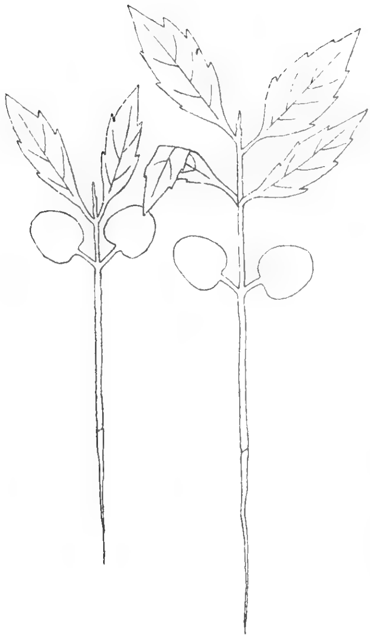
Plate I. Seedlings in various stages of the following plants: *Populus deltoides*, *Ulmus americana*, *Celtis occidentalis*, *Toxylon pomiferum*, *Broussonetia papyrifera*, *Liriodendron tulipifera*, *Butneria florida*, *Parkinsonia aculeata*.

Plate II. Seedlings in various stages of the following plants: *Cercis canadensis*, *Amorpha fruticosa*, *Amorpha nana*, *Robinia pseudacacia*, *Ptelea trifoliata*, *Ailanthus glandulosa*, *Schinus molle*, *Celastrus scandens*.

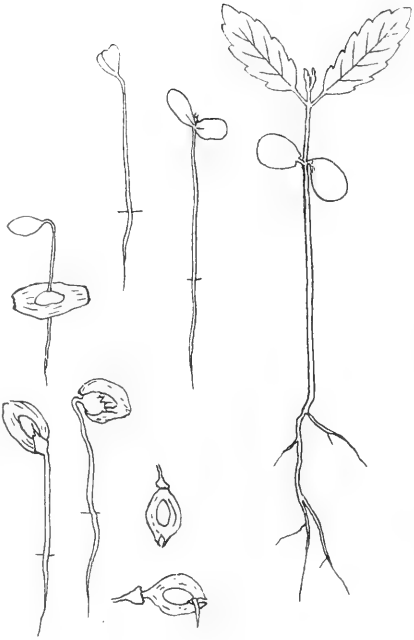
Plate III. Seedlings in various stages of the following plants: *Acer negundo*, *Acer saccharinum*, *Acer glabrum*, *Berchemia racemosa*, *Rhamnus purshiana*, *Vitis cordifolia*, *Parthenocissus quinquefolia*, *Sterculia plantanifolia*.

Plate IV. Seedlings in various stages of the following plants: *Elæagnus umbellata*, *Eucalyptus globulus*, *Eucalyptus citriodora*, *Cornus amomum*, *Mohrodendron carolinum*, *Catalpa speciosa*, *Tecoma radicans*, *Cephalanthus occidentalis*, *Sambucus pubens*.

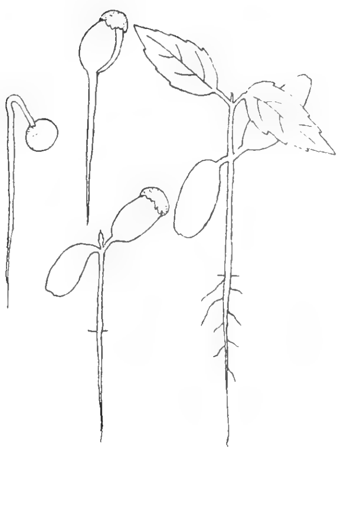
The amount of enlargement or reduction is indicated for each plant.



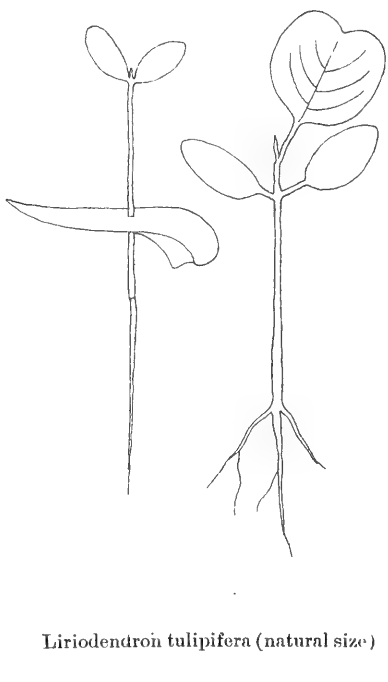
Populus deltoides x 1½



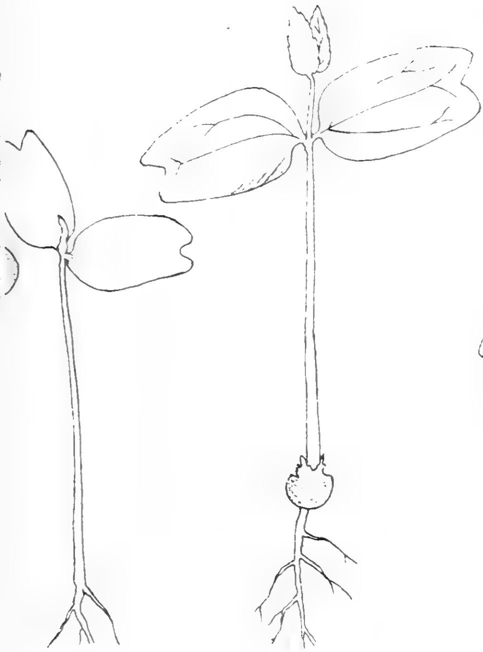
Ulmus americana x ¾



Broussonetia papyrifera x 1½



Liriodendron tulipifera (natural size)



Celtis occidentalis x $\frac{3}{4}$

Toxylon pomiferum x $\frac{3}{4}$

Butneria florida x $\frac{3}{4}$

Parkinsonia aculeata x $\frac{3}{4}$

TE I.

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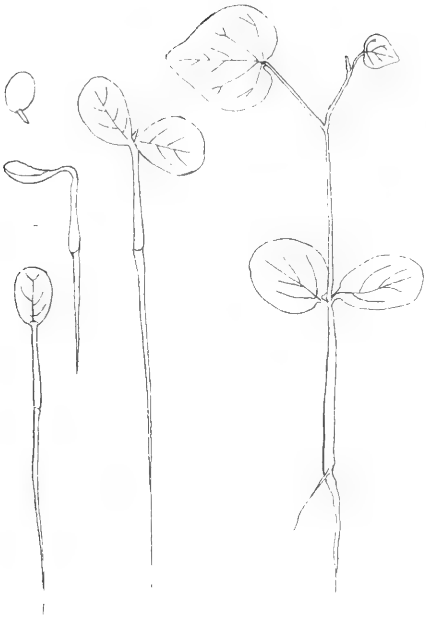
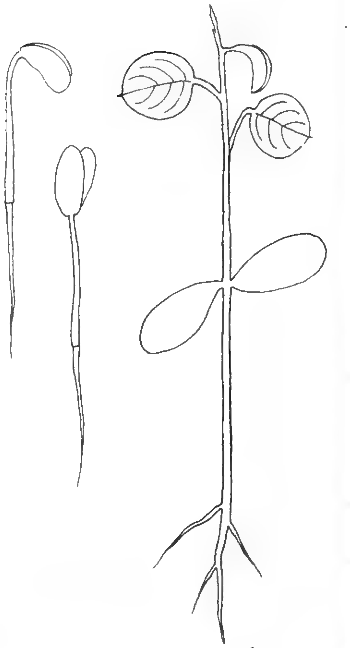
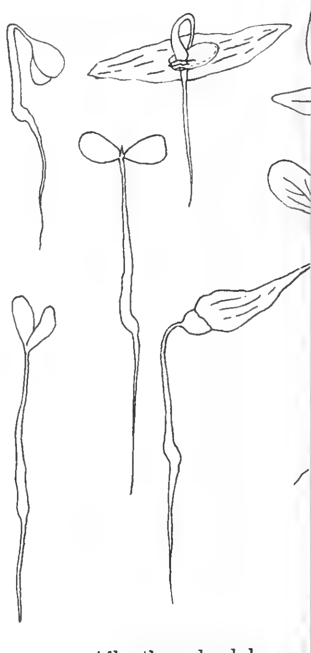


Cercis canadensis x $\frac{3}{4}$



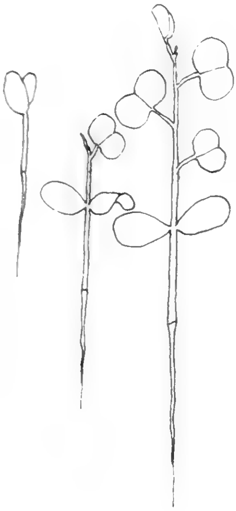
Amorpha fruticosa x $1\frac{1}{2}$

Ptelea trifoliata x $\frac{3}{4}$



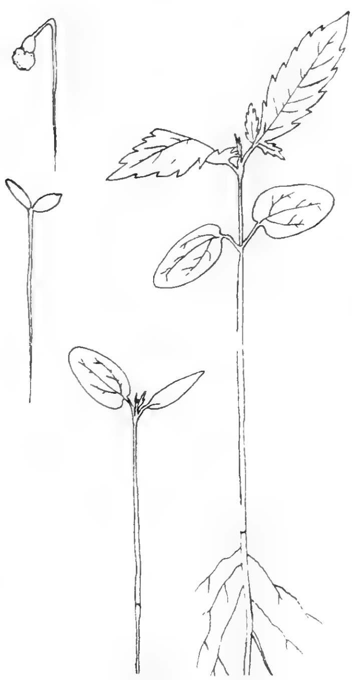
Ailanthus glandulosa x

PL

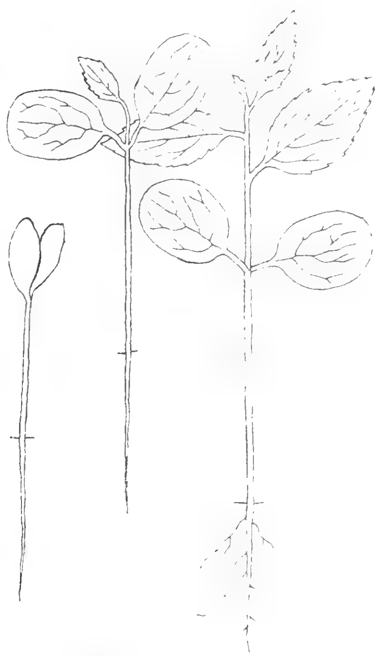


Amorpha nana x $1\frac{1}{2}$

Robinia pseudacacia x $\frac{3}{4}$

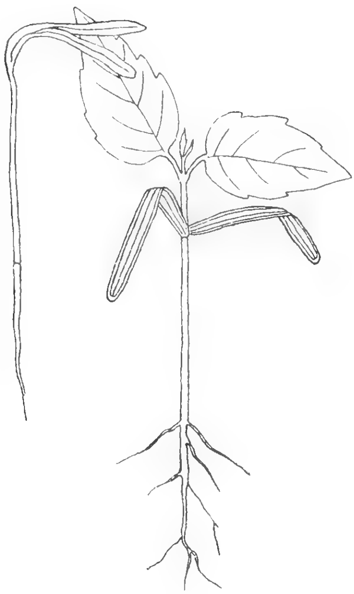


Schinus molle x $\frac{3}{4}$

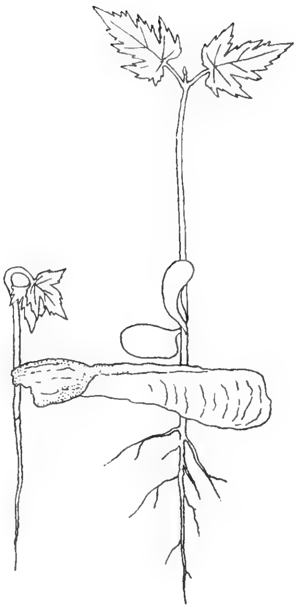


Celastrus scanaens x $\frac{3}{4}$

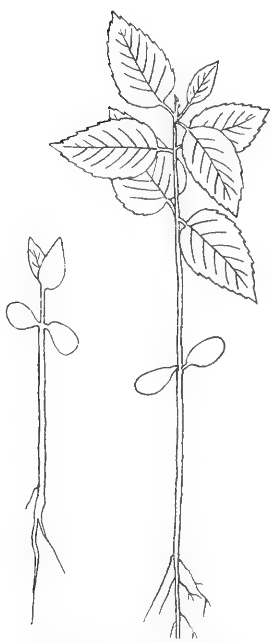
'E II.



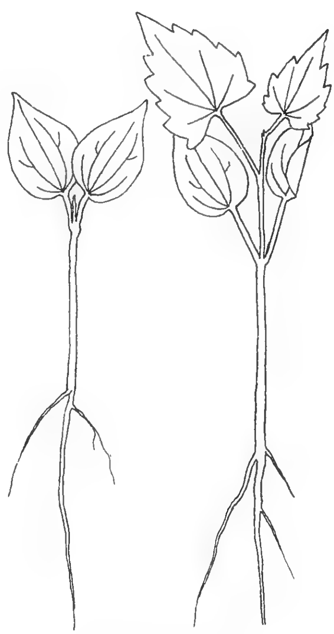
Acer negundo x $\frac{3}{4}$



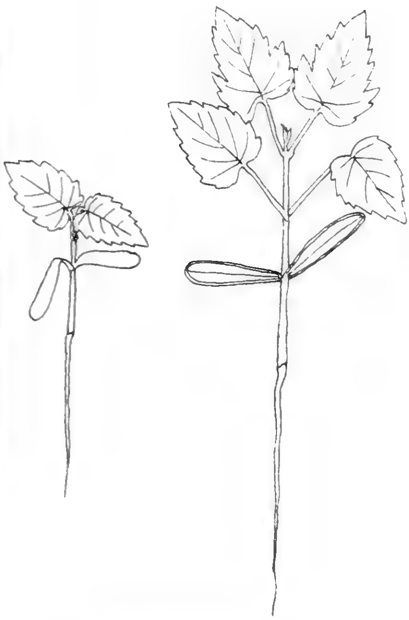
Acer saccharinum x $\frac{3}{4}$



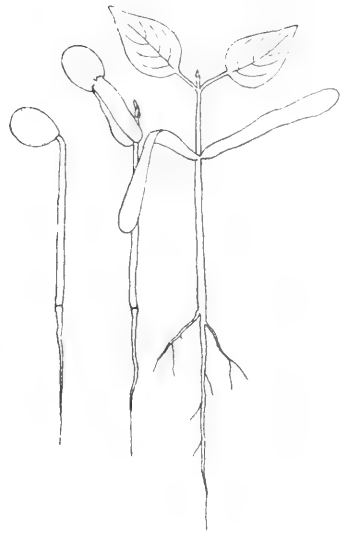
Rhamnus purshiana x $\frac{3}{4}$



Vitis cordifolia x $\frac{3}{4}$

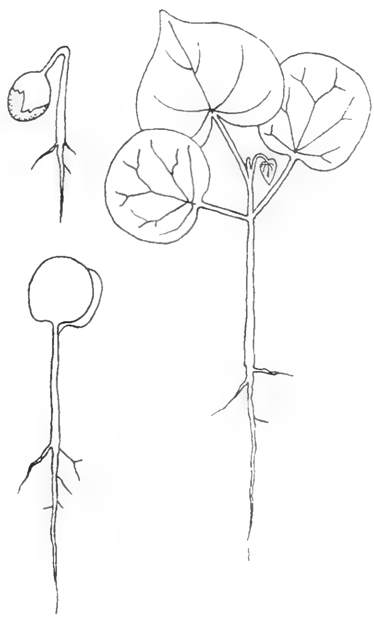


Acer glabrum x $\frac{3}{4}$



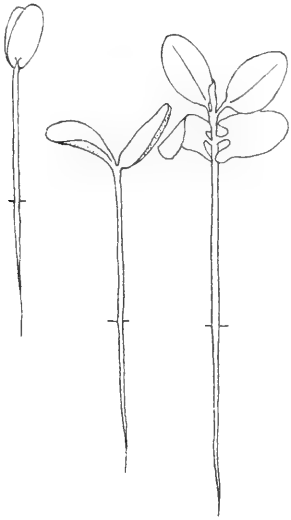
Berchemia racemosa x $1\frac{1}{2}$

Parthenocissus quinquefolia x $\frac{1}{3}$

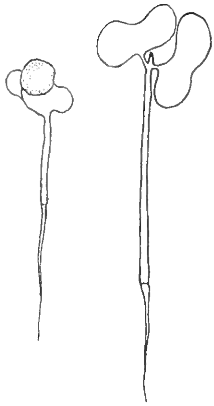


Sterculia platanifolia x $\frac{1}{3}$

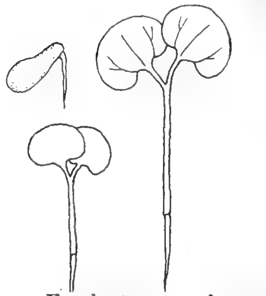
TE III.



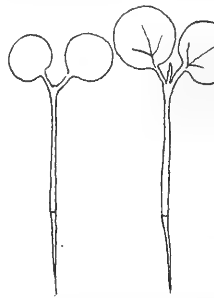
Elaeagnus umbellata x $1\frac{1}{2}$



Eucalyptus globulus
(natural size)



Eucalyptus corymbosa
(natural size)



Eucalyptus citriodor
(natural size)

Catalpa speciosa x $\frac{3}{4}$

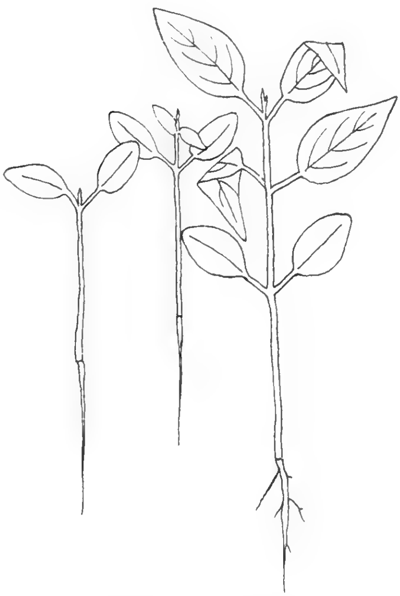
Tecoma radicans x $\frac{3}{4}$

PLAT

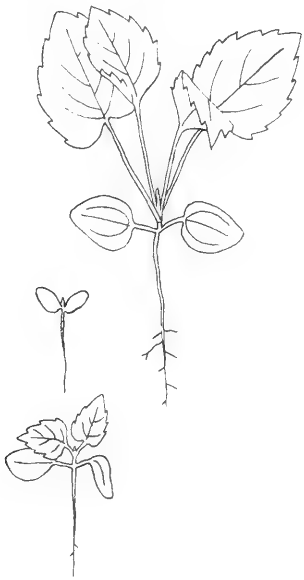
HELIOTYPE PRI

Cornus amomum x ¾

Mohrodendron carolinum x ¾



Cephalanthus occidentalis x 1½



Sambucus pubens x ¾

V.

IX. COMPARATIVE ANATOMY OF HYPOCOTYL AND EPICOTYL IN WOODY PLANTS.

FRANCIS RAMALEY.

The following is an account of the anatomy of seedlings of certain woody dicotyledonous plants. These plants were studied: *Ulmus americana* LINN., *Celtis occidentalis* LINN., *Toxylon pomiferum* RAF., *Broussonetia papyrifera* (LINN.) VENT., *Liriodendron tulipifera* LINN., *Menispermum canadense* LINN., *Butneria florida* (LINN.) KEARNEY, *Parkinsonia aculeata* LINN., *Cercis canadensis* LINN., *Gleditsia triacanthos* LINN., *Amorpha fruticosa* LINN., *Robinia pseudacacia* LINN., *Ptelea trifoliata* LINN., *Ailanthus glandulosa* DESF., *Schinus molle* LINN., *Berchemia racemosa* SIEB. & ZUCC., *Rhamnus purshiana* DC., *Vitis cordifolia* MICHX., *Elaeagnus umbellata* THUNB., *Eucalyptus globulus* LABILL., *Tecoma radicans* (LINN.) DC., *Catalpa speciosa* WARDER, *Cephalanthus occidentalis* LINN. The order in which they are described is that of Engler and Prantl. This order will be followed throughout.

The author is under obligation to Professor Conway MacMillan, who suggested the subject of the investigation and under whose direction the work has been completed.

The seedlings were grown at the University of Minnesota during the years 1896, 1897 and 1898. They were examined at different ages so that the original structure of both hypocotyl and epicotyl could be noted as well as the differences brought about through secondary changes.

For the sake of convenience and uniformity three stages were studied; these may be designated as first, second and third stages. A seedling with the cotyledons expanded but with the epicotyl undeveloped is said to be in the first stage. Obviously only the structure of the hypocotyl was studied in this stage. In the second stage the epicotyl has elongated and the first foliage leaves have appeared. In the third stage a considerable number of foliage leaves have been developed and the anatomical structure has, to a considerable extent, taken on its permanent characters. Sections were also, in many cases, cut from material two years old for purposes of comparison.

Since the structure of the hypocotyl is often materially different in all the three mentioned stages, it has seemed important to make a record of the changes which take place during the first year's growth. Previous investigators have not done this.

A number of investigators who have made a comparative study of root and shoot have incidentally examined the hypocotyl, *e. g.*, Goldsmith [1876] and Gérard [1880 and 1881]. The latter made some careful observations on the course of vascular bundles from the cotyledons to the root. His statement that the characteristic root structure often extends as high as the cotyledons is not, in general, confirmed by the present investigation.

The most important articles* which need to be mentioned at the present time are by Dangeard [1888 and 1889], Van Tieghem [1891], and Flot [1889 and 1890]. Dangeard begins with a study of the structure of roots, of which he distinguishes three types. In the first type the root is diarch; the hypocotyl has four bundles in two pairs which arise as cotyledonary trace bundles by the division of the midrib of each cotyledon. In the second type the root is tetrarch; the hypocotyl has eight bundles in four groups. In the third type the root is octarch, while the hypocotyl has sixteen bundles in eight groups. The first type of structure of the hypocotyl above mentioned is the one commonly found in the plants studied by the present writer who has called it the "typical structure." (See General Conclusions at the close of this paper.)

Flot [1889, 1890] describes the "region tigellaire," a much thickened portion of the axis of certain year-old seedlings. The region extends from the base of the hypocotyl up to the first foliage leaf or to some point between that and the cotyledons. It is noted only in certain species. It is not the same as the "tigelle," which extends only as high as the cotyledons. The "region tigellaire" is characterized by only a slight development of sclerenchyma and of normal phloem, while internal phloem is probably altogether absent. The pericycle, he says, is well developed.

Van Tieghem [1891] divides the hypocotyl into "tigelle" and "rhizelle." The growth of the hypocotyl is produced by the elongation of either the tigelle, as in *Ricinus*, *Acer*, *Cucur-*

* Search has been made, but without success, for a paper by Monal: Rech. sur l'anat. compar. de la tige hypocot. et epicot.

bita, *Tagetes*, *Convolvulus* and *Mirabilis*, or, the rhizelle, as in Ranunculaceæ, Cruciferæ, Caryophyllaceæ, Chenopodiaceæ, Umbelliferæ, Rubiaceæ and Coniferæ, or by a combination of the growth of both as in *Euonymus*.

The designation of certain regions as tigelle, rhizelle and tigellaire does not seem to the present writer a matter of great importance in the plants which he has studied, for in them these regions are by no means sharply differentiated. Further observations and references to the work of Flot mentioned above are given in the pages which follow.

In the special portion of the present work will be found descriptions of the structure of hypocotyl and epicotyl in the various species examined. Accompanying each description is a diagram of the cross section of the hypocotyl when the seedling is in the first stage previously described, and diagrams of both hypocotyl and epicotyl of the second and third stages. In these diagrams stereom is black, xylem is dotted, cortex, phloem, pericycle and the pith are white. The endodermis, when distinct, is indicated by a single line as is also the epidermis and the boundaries between the various zones. In each figure the diagrams of the hypocotyl are at the left, those of the epicotyl at the right.

ULMACEÆ.

Ulmus americana.

Structure of Hypocotyl.

The epidermis is composed of cells which, in cross section, are square or rounded. After secondary growth of the stele has commenced these cells become very much flattened. There is no hypoderma differentiated. The cells of the cortex are large; all are about the same size.

The endodermis is small-celled and is easily recognized in early stages, when it contains very little starch. Afterward starch becomes abundant in the endodermis, pericycle, cortex, phloem and inner xylem.

In the stele there are many small phloem bundles which are confluent into two crescent-shaped areas. There are two xylem bundles of somewhat crescentic appearance in cross section. The xylem and phloem soon form closed rings.

The pericycle, in seedlings which have about two internodes of the stem developed, is partially sclerenchymatous. At a later time numerous groups of sclerenchyma are found in the phloem and cortex.

The pith becomes quite small. There is a small-celled perimedullary zone.

The formation of cork cambium, as noted by Flot ([1890], p. 29), takes place in the inner cortex.

Structure of Epicotyl.

The cells of the epidermis when seen in cross section, are somewhat rectangular in outline. The tangential diameter is the longer. Numerous hairs are present. No collenchymatous hypoderma is produced. The cortex is rather narrow. The cells are all about the same size.

The endodermis is distinct only in young material. The cells are small. They contain starch. At the end of the season starch is found in the pith and inner xylem and is sparingly distributed in the cortex and phloem.

In the youngest material examined the phloem forms a closed ring surrounding a number of xylem groups. There are usually eight of these. They soon fuse to form a complete ring.

Numerous small groups of thick-walled cells finally make their appearance in cortex, pericycle and phloem.

The pith becomes quite small. The cells have thin unlignified walls. The perimedullary zone is easily distinguished; it consists of from one to three layers of small cells which are often somewhat flattened.

Cork formation, as is well known in this species, begins in the outermost cell layer of the cortex.

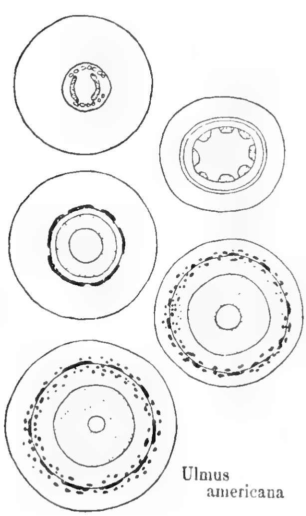


FIG. 1.

Comparison of Structure of Hypocotyl and Epicotyl.

The epidermal cells of the hypocotyl in young material appear radially elongated, those of the epicotyl tangentially elongated. The former region has a thicker cortex, fewer epidermal hairs, sclerenchyma developed earlier in the pericycle.

The stele of the hypocotyl has two xylem bundles and two aggregations of phloem bundles. In the epicotyl the youngest material examined has a complete ring of phloem and about eight xylem bundles. Cork formation in the former region takes place deep in the cortex instead of in the outermost cortical layer.

In their final structure the two regions are practically alike.

Celtis occidentalis.

Structure of Hypocotyl.

The epidermis is composed of thin-walled cells, small, square in cross section. There is no hypoderma. The elements of the cortex are large. There are about twenty layers of cells.

The cells of the endodermis are much smaller than those of the cortex and on this account the endodermis is readily distinguished until considerable secondary growth of vascular tissue has taken place.

Starch is found in the endodermal region from the first; toward the close of the season it is found not only in the pith, phloem and cortex, but very abundantly distributed throughout the xylem. Large isodiametric crystals, long known in the stem of this species (Moeller [1882], p. 74), make their appearance in the cortex some time before the close of the first season.

The stele, which is cylindrical from the first, has originally four xylem bundles and two crescentic masses of phloem. At an early stage the xylem forms a closed ring, while it is not till sometime afterward that the two areas of the phloem become united.

Two interrupted rings of sclerenchyma appear later in the first season, one of these is in the cortex and consists of much larger groups of cells than does the other which is in the outer phloem.

The pith is large-celled. A more or less definite perimedullary zone of small cells is at length developed.

Cork formation begins at a late period in the outermost cell layer of the cortex.

Structure of Epicotyl.

The cells of the epidermis are at first nearly square in cross section but at a later time are considerably flattened. There are numerous simple curved and pointed hairs; there are also some with bulbous ends.

The cortex is thin. A distinct collenchymatous hypoderma is developed. It usually consists of three or four layers of cells.

The endodermis, which is originally distinct, soon becomes unrecognizable. The cells are about the same size as those of the cortex; they contain starch. Eventually all the parenchymatous elements contain starch.

The stele is originally somewhat elliptical in cross section. The phloem, in the youngest material examined, forms a complete ring. There are generally two large and four small xylem bundles. These soon fuse to form a closed xylem zone.

An interrupted band of sclerenchyma is developed at the outer limit of the xylem.

As in *Celtis australis* (cf. Flot [1893], p. 68) there is a distinct perimedullary zone composed of two or three cell rows.

Cork formation begins, rather late in the season, in the outermost hypodermal layer (cf. Moeller [1882], p. 74).

Comparison of Structure of Hypocotyl and Epicotyl.

A striking difference between hypocotyl and epicotyl is the absence from the former region of the numerous epidermal hairs so abundant in the latter. The hypocotyl is without a hypoderma.

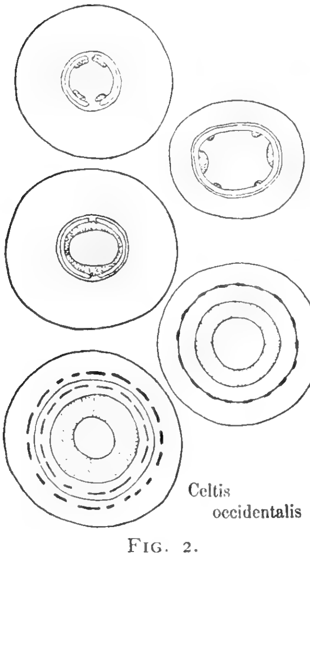


FIG. 2.

The primary stelar structure of the hypocotyl is peculiar, the phloem forming two crescentric masses and not uniting into a closed ring till after the xylem bundles have fused. The epicotyl possesses a ring of phloem and six xylem bundles.

At the end of the season the hypocotyl has two interrupted bands of sclerenchyma instead of one, and a smaller pith. Aside from these differences the two regions are the same in structure.

MORACEÆ.

Toxylon pomiferum.

Structure of Hypocotyl.

In cross section the cells of the epidermis appear radially elongated. Eventually they are considerably flattened. The cells of the outer cortex are similar to those of the epidermis. There is no collenchyma developed. The inner cortex is composed of larger cells.

The endodermis is distinct but in material taken at the close of the growing season it was not distinguished. The development of pericycle is remarkable. This region is composed of about six layers of parenchymatous cells resembling, in shape, those of the endodermis.

Starch is found, from the first, in the endodermis and later appears in all the conjunctive tissues.

The stele is slightly four-angled. There are, in the youngest material examined, four xylem bundles and two large crescent-shaped phloem bundles. The phloem soon forms a complete ring as does also the xylem, but the two xylem bundles first fuse in pairs.

About this time four aggregations of small groups of sclerenchyma appear in the pericycle. Eventually a nearly complete sclerenchymatous ring surrounds the phloem.

The pith is large-celled. A small-celled perimedullary zone of three or four layers is present.

Cork formation takes place in the fourth or fifth layer of the cortex.

Structure of Epicotyl.

The epidermis is composed of cells which are, at first, nearly square in cross section but later are very much flattened. According to Moeller [1882] the epidermis is two-layered. Numerous straight epidermal hairs are present; there are also some stalked glandular hairs. The cells of the cortex are rather small, parenchymatous, not at all collenchymatous.

The endodermis is distinguished with difficulty even in very young material. Its cells contain starch. Starch is later found in all the parenchymatous tissues.

There is a variable number of vascular bundles; usually eight to sixteen. These soon fuse to form closed rings of phloem and xylem.

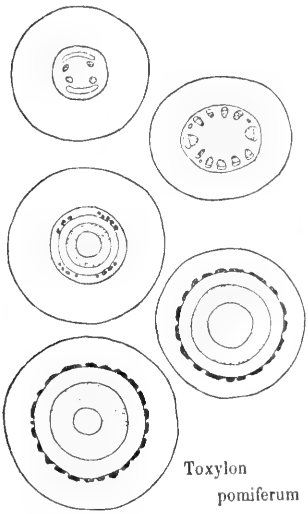
An interrupted sclerenchymatous ring is formed at the outer edge of the phloem; the cells are thick-walled but do not become lignified the first year.

The pith is rather large. There is a small-celled perimedullary zone which is quite definite.

Cork formation in the epicotyl takes place in the outermost cortical layer (cf. Moeller [1882]).

Comparison of Structure of Hypocotyl and Epicotyl.

In the hypocotyl the cortex and pericycle are much better developed than in the epicotyl. The former region is without epidermal hairs. This point of difference was previously noted by Klebs [1885].



Toxylon pomiferum

Fig. 3.

The stele of the hypocotyl has originally four vascular bundles, instead of from eight to sixteen; the pith is small in extent.

The sclerenchyma is first formed in four patches but afterwards forms almost a complete ring. Cork formation in the hypocotyl begins in a deeper layer of the cortex.

At the close of the year the two regions have nearly the same structure, about the only difference being the size of the pith.

Broussonetia papyrifera.

Structure of Hypocotyl.

There is an epidermis of small cells nearly square in outline when seen in cross section. These cells become greatly elongated tangentially as the tissues within increase in thickness. Short, blunt, unicellular epidermal hairs are numerous.

The cortex is composed of about six layers of large, thin-walled parenchymatous elements which, like the epidermal cells, become stretched toward the close of the season.

The endodermis is small-celled. It sometimes remains distinct till nearly the close of the first season. Starch is present in the endodermis, but absent from all other tissues for a long time. It eventually appears in the pericycle, phloem, medullary rays and inner elements of the xylem.

The stele is originally very small. In the disposition of the vascular tissues this plant differs from all others examined by the writer. In cross section the center of this stele is seen to be occupied by an elongated area of xylem. On each side of this, separated by a small amount of conjunctive tissue, is a crescent-shaped mass of phloem. The xylem soon forms a somewhat four-sided mass, and is surrounded by a ring of phloem. The xylem at length becomes circular, and the surrounding phloem increases greatly in amount.

There is but slight development of stereom, although, toward the close of the first season, numerous isolated sclerenchymatous elements are found in the phloem.

The cork cambium originates in the endodermis or pericycle. The ring of phellogen is sometimes irregular, appearing now in one, now in the other of the regions named.

It may be said that, since the structure of the hypocotyl in this species so much resembles the general type of root structure, it was thought best to examine a large number of plants, lest the peculiarities noted should have been due to teratological development. All the plants were, however, found to be alike. Neither is there any trouble in this species, to determine the lower limit of the hypocotyl, for it is enlarged below and does not gradually shade off into root, as is the case in some seedlings.

Structure of Epicotyl.

The epidermis is small-celled. There are numerous simple, blunt and pointed hairs, and also some with a single stalk cell and a multicellular bulb at the distal end.

A somewhat collenchymatous hypoderma is developed, consisting of two or three layers of cells, which are smaller than the deeper cells of the cortex.

The small-celled endodermis, at first distinct, soon becomes displaced and changed, owing to secondary growth of sub-lying tissues.

Starch is almost entirely absent, except in the endodermal region, till about the close of the first growing season, when it appears in the pith, medullary rays, phloem and, to a slight extent, in the cortex.

The stele is large. There is a circle of twelve to eighteen conjoint vascular bundles. These soon fuse to form a narrow zone each of xylem and phloem.

There is a considerable amount of sclerenchyma at the outer edge of the phloem. The cells are, however, mostly isolated or else occur in small groups.

The pith, which is extensive, is composed of large, parenchymatous elements with thin, slightly lignified walls. According to Flot [1893], there is a perimedullary zone of five or six layers of crushed, thin-walled cells. The same author states that laticiferous tubes are found in the perimedullary region of young twigs of this species.

The cork cambium is formed in the outermost hypodermal layer (cf. Moeller [1882], p. 82).

Comparison of Structure of Hypocotyl and Epicotyl.

Both hypocotyl and epicotyl have simple epidermal hairs, but the former does not have the pointed or the bulbous hairs found in the latter region. The hypocotyl is also without the somewhat collenchymatous hypoderma found in the epicotyl; its endodermis persists for a greater length of time.

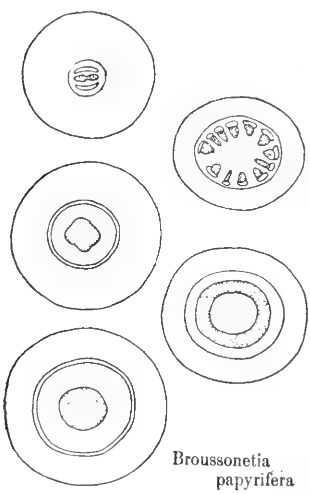


FIG. 4.

The structure of the stele in the hypocotyl is anomalous. A single flat bundle of xylem is flanked by phloem, which eventually surrounds the centrally-lying xylem, the inner cells of which contain starch. There is no pith. The epicotyl, on the other hand, has a large pith, and the vascular bundles are originally numerous. Starch is absent from the xylem.

Cork formation is endodermal or pericyclic in the hypocotyl, but hypodermal in the epicotyl.

MAGNOLIACEÆ.

Liriodendron tulipifera.

Structure of Hypocotyl.

The epidermis consists of cells which are nearly square in cross section; at first they are very much bulged. They never become flat. The two or three layers of the cortex just below the epidermis are small-celled. The deeper layers are very large-celled.

The endodermis is small-celled and easily distinguished in young material, but is eventually displaced and is not distinguishable. In the young stages starch is entirely absent from the hypocotyl, but later is found sparingly distributed through the various parenchymatous tissues.

The stele, which is originally quadrangular, has four vascular bundles arranged in pairs. By their continued growth zones of xylem and phloem are produced.

About the time that a complete ring of xylem has been formed four masses of sclerenchyma appear in the pericyle. Eventually other groups of pericyclic cells also become sclerotic. The phloem immediately under these groups is better developed than at other places.

The pith is slightly quadrangular. The cells are thin-walled. A definite perimedullary zone was not distinguished.

The cork cambium is produced in the outermost layer of cortical cells.

Structure of Epicotyl.

The cells of the epidermis, when seen in cross section, appear square or tangentially elongated. A narrow collenchymatous hypoderma is developed. The remaining cells of the cortex are all about the same size.

The endodermis is distinct in young material, owing to the presence of starch in its cells. At a later time starch is distributed in small amount in the various parenchymatous tissues.

The number of primary xylem groups in the stele is about six or eight. Groups of phloem are somewhat more numerous. Closed zones of xylem and phloem are produced very early.

The outer phloem has many groups of sclerenchymatous fibers. These groups are close together, separated only by medullary rays. A small amount of sclerenchyma is produced in the cortex.

The pith is rather large, and composed of cells with thin, unlignified walls. No perimedullary zone was distinguished.

Cork is developed in the outermost cell layer of the cortex (cf. Moeller [1882], p. 229).

Comparison of Structure of Hypocotyl and Epicotyl.

The cortex of the hypocotyl is much thicker than that of the epicotyl. The former region has no hypoderma; it has four vascular bundles instead of six or eight or more; the sclerenchyma first appears in only four groups and at no time is as well developed as in the epicotyl.

The pith of the hypocotyl is smaller than that of the epicotyl; it is somewhat quadrangular in shape.

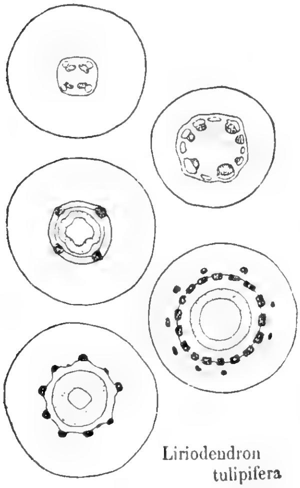

Liriodendron tulipifera

FIG. 5.

MENISPERMACEÆ.

Menispermum canadense.

Structure of Hypocotyl.

The epidermis consists of cells which are square or rectangular in cross section. Late in the first season they become flat and tangentially elongated. A very thick, tough cuticle develops at the same time.

There is no hypoderma. There are about twelve layers in the cortex. The cells are large.

The endodermis consists of cells smaller than those of the cortex. It remains distinct a long time, but was not distinguished in material taken at the close of the growing season. The pericycle is peculiar. It is one or two layers in thickness. Usually every second or third cell, when seen in cross section, is without starch, although starch is present in the other cells. Eventually these cells also contain starch.

This plant is somewhat unique in the distribution of starch in its tissues, for in all the different stages examined starch was found in cortex, pith, endodermis and medullary rays and in the pericycle except as just noted.

The stele is quadrangular and has four primary vascular bundles. These increase considerably in size as the plant grows older. At the close of the growing season they are of about the same extent as the medullary rays which are composed of wood parenchyma and are full of starch. There is no phloem produced the first year opposite the medullary rays.

The pith is composed of large cells. There is a rather distinct smaller-celled perimedullary zone. No cork is formed the first year.

Structure of Epicotyl.

The cells of the epidermis, at first square in cross section, become very much flattened and develop a thick cuticle like that of the hypocotyl. A more or less definite collenchymatous hypoderma is developed. The cortex is composed of about six cell layers.

The endodermis is not easily distinguished even in youngest stages. The pericycle has some cells which in cross section appear empty, while the neighboring cells contain starch. These empty cells at a later time either become filled with starch or else are displaced so that they are not recognized.

Starch is present in the cortex, medullary rays, endodermis, pericycle and pith.

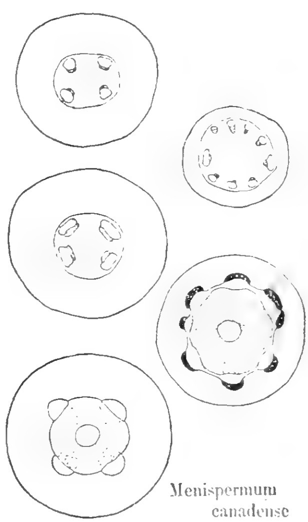
There are originally from nine to fifteen vascular bundles. These usually fuse to some extent so that there come to be only about six or eight. These remain easily distinguishable, since the primary medullary rays are very broad. The growth of the cambium produces no true phloem elements opposite the medullary rays, although there is some thin-walled parenchyma.

A crescent-shaped area of stereom is finally formed at the outer edge of each phloem bundle.

The pith becomes rather small in extent. There is a perimedullary zone of two or three layers of smaller cells. According to Flot [1893] these form at a later time five or six layers of sclerotic parenchyma. The formation of cork was not observed. It does not take place the first year.

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl has a thicker cortex than the epicotyl: it is without a collenchymatous hypoderma. The endodermis is much more distinct in the former region and the peculiar distribution of starch in the pericycle is more pronounced.



Menispermum canadense

FIG. 6.

Concerning the structure of the stele it is to be noted that in the hypocotyl it is quadrangular; it has but four vascular bundles instead of from eight to twelve and there is no stereom, while in the epicotyl a crescentic mass of stereom borders each phloem bundle.

CALYCANTHACEÆ.

Butneria florida.

Structure of Hypocotyl.

The epidermis consists of cells which are nearly square in cross section. They soon become more or less broken, owing to the early formation of cork. A few short, pointed, unicellular hairs are present.

A true hypoderma becomes differentiated late in the season. About three or four of the sub-epidermal layers of cells become collenchymatous. The cortex has about twenty layers of cells all approximately the same size. Intercellular spaces abound.

The endodermal cells are but slightly smaller than those of the cortex. The endodermis remains more or less distinct until the close of the first year. Starch grains are very small. A few are found in the endodermis, but no starch is present in the other parts of the hypocotyl till late in the season, when it is found in great abundance throughout all the parenchymatous tissues.

The stele is somewhat quadrangular. There are four xylem bundles and four principal phloem bundles. These are situated in the angles of the stele. There are also some small phloem areas. Their location will be seen by reference to the diagram. The phloem and xylem soon form narrow, closed zones. The former is most developed at the original angles of the stele.

It is stated by De Bary [1884], that in the seedlings of Calycanthaceæ a transverse section of the hypocotyl shows six bundles. In the plant under investigation, the present writer found this to be true only for the upper end of the hypocotyl where the cortical bundles, to be mentioned later, are separating and preparing to leave the stele. This appearance is, of course, only seen after the fusion of the primary xylem bundles in pairs, and before complete rings of phloem and xylem are produced.

Toward the upper limit of the hypocotyl there is present a small stereom bundle at each of the four angles of the stele.

These stereom bundles bend outward and accompany the cortical bundles in succeeding internodes.

The pith is rather thick-walled; the cells are about the same size as those of the cortex. A small-celled perimedullary zone of one or two layers is at length clearly distinguishable.

Cork formation begins very early in the outermost sub-epidermal layer of the cells.

Structure of Epicotyl.

The cells of the epidermis when seen in cross section are rectangular with the long diameter parallel to the surface of the section. There are numerous pointed hairs of various lengths.

A collenchymatous hypoderma, four or five layers of cells in thickness, forms the outer part of the cortex, the rest of which is composed of very loose parenchyma.

A definite endodermis was not distinguished. The endodermal region is, however, easily recognized by the presence of starch in many of the cells. Starch is afterward found in great abundance in pith, cortex and medullary rays.

The normal phloem and xylem form closed rings even in the youngest material examined. In the cortex, about half way between the epidermis and phloem are four vascular bundles, ninety degrees apart; each bundle consists of a more or less crescent-shaped mass of lignified sclerenchyma, at whose concave surface is a small area of slightly lignified xylem, consisting usually of five to ten cells. Adjoining this xylem and projecting some distance toward the stele is a lenticular mass of phloem. The general arrangement of the bundle is the same as that carefully described for *Calycanthus* sp. by Woronin [1860] and for *Calycanthus occidentalis* by Williams [1894]. Serial sections showed that in this species these cortical bundles enter the stele about 1 mm. below the insertion of the cotyledons, and not at the middle of the first internode as reported by Herail [1885] for certain other species.

The pith is large. There is a definite perimedullary zone of about three layers of small cells.

The cork cambium is formed very early in the outermost hypodermal layer (cf. Moeller [1882], p. 364).

Comparison of Structure of Hypocotyl and Epicotyl.

The epidermal hairs of the hypocotyl are fewer and shorter than those of the epicotyl. There is in the former region also a less developed hypoderma.

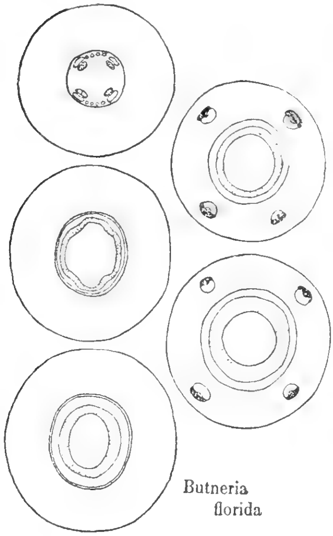


FIG. 7.

The stele of the hypocotyl is originally quadrangular; it is surrounded by a distinct endodermis, and has four xylem bundles and four principal phloem bundles. The stele of the epicotyl is cylindrical, without a distinct endodermis, and even at a very early age, the xylem and phloem form closed rings.

The hypocotyl has no cortical vascular bundles; of these the epicotyl has four.

The presence of true collenchy matous hypoderma in the hypocotyl deserves special mention, as this forms an exception to the general rule that collenchyma is not developed in the hypocotyl.

CÆSALPINACEÆ.

Parkinsonia aculeata.

Structure of Hypocotyl.

The epidermis is composed of cells which are rectangular in cross section. They are, at first, radially elongated. Eventually they become elongated in the other direction.

The cortex is many-layered. There is no hypoderma. The outer cells of the cortex are much smaller than those further down. Very early in the history of the hypocotyl a parenchymatous sheath of small cells is formed in the cortex about midway between epidermis and endodermis. The cells are not arranged in definite rows. The position of this sheath is shown in the last plate accompanying this paper.

The cells of the endodermis are smaller than those of the cortex. They contain starch. The endodermis is quite distinct; it was, however, not definitely distinguished in material collected late in the season. The cortex and pith at a later time also have some starch.

The stele is four-angled. There are originally four phloem bundles and eight paired xylem bundles. Eventually closed rings of xylem and phloem are formed.

At the corners of the stele in the pericycle groups of sclerenchyma are formed. The cells become very thick-walled and each group quite large.

The pith is large. The cells are rather thick-walled. No definite perimedullary zone was distinguished.

In the material examined cork formation had not commenced.

Structure of Epicotyl.

The epidermal cells are thin-walled, square in cross section, becoming at length much flattened. There is no collenchyma. The cortex is narrow; the cells are about the same size as those of the epidermis.

The endodermis is composed of thin-walled cells. After secondary growth of the stelar tissues it cannot be definitely seen. The cells are about the same size as those of the cortex; they contain starch. Starch is found at a later time in the various parenchymatous tissues.

The number of vascular bundles is variable. Usually there are about twelve. These, at length, fuse to form closed rings of phloem and xylem.

The pericycle develops a sheath of sclerenchyma which almost completely shuts in the phloem. The cells were not very thick-walled in the material examined.

The pith is large, the cells rather thin-walled. A perimedullary zone of small-celled parenchyma at length becomes differentiated.

No material old enough to show cork formation was examined.

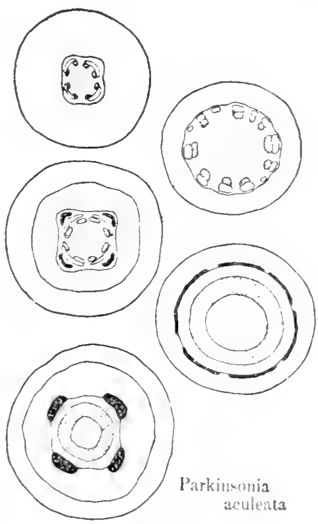


FIG. 8.

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl differs from the epicotyl in having a thicker cortex with a narrow small-celled parenchymatous sheath. The cells of the cortex are also larger.

In its primary stelar structure the differences are very marked. The hypocotyl has four phloem bundles and eight xylem bundles instead of a large number of conjoint bundles. It has four large groups of stereom instead of a narrow, almost continuous sclerenchymatous sheath.

Cercis canadensis.

Structure of Hypocotyl.

The epidermal cells are rectangular in cross section; the radial diameter is the longer. These cells never become tangentially elongated. The cells of the outer cortex are smaller than those within. An indefinite sheath of small-celled parenchyma similar to that in *Parkinsonia* can sometimes be recognized.

The endodermis is small-celled; it remains distinct through the first year. Its cells contain starch. Starch is also present toward the close of the year in the pith.

The stele is originally quadrangular. There are four xylem bundles and four phloem bundles. These, at length, develop into closed rings.

Four small groups of sclerenchyma make their appearance in the pericycle at an early time and become, at length, considerably extended.

The pith finally becomes cylindrical. The cells are large and thin-walled. The perimedullary zone is not clearly differentiated.

Cork formation takes place in the cortex either next to or very near the endodermis. It begins sometime before the close of the season.

Structure of Epicotyl.

The epicotyl is somewhat quadrangular in the early stages. The epidermal cells are rectangular in cross section. The tangential diameter is the greater. There is no hypoderma. The cortex is thin. The cells are all about the same size.

The endodermis was not definitely distinguished. In the youngest material examined the phloem forms a closed ring. There are four large primary xylem bundles. There are also some smaller ones. The latter have often only one or two xylem cells. A closed zone of xylem is soon produced.

Nearly all the cells of the pericycle become, at length, sclerotic, thus forming an almost continuous sheath with but few parenchymatous cells.

The pith is large-called. A perimedullary zone was not distinguished.

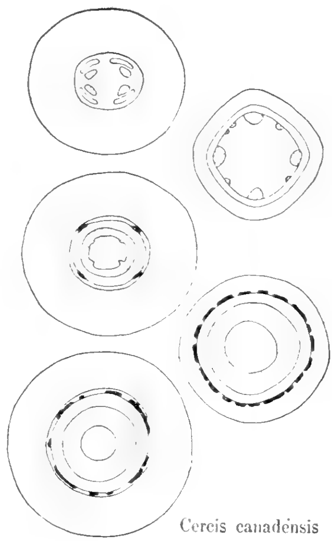
Cork formation takes place in the second cortical layer as in *Cercis siliquastrum* (fide Moeller [1882]).

Comparison of Structure of Hypocotyl and Epicotyl.

The epidermal cells of the hypocotyl, when seen in cross section, appear radially, not tangentially elongated as in the epicotyl. In the former region the endodermis is distinct, the cortex thicker and the sclerenchyma at first differently disposed.

The stele of the hypocotyl has originally four phloem bundles and four xylem bundles. The youngest material of the epicotyl which was examined has a closed ring of phloem and four large xylem bundles, also a few small groups of xylem.

Cork formation in the hypocotyl takes place in the lower cortex; in the epicotyl it takes place in the second cell layer of the cortex.



Cercis canadensis

FIG. 9.

Gleditsia triacanthos.

Structure of Hypocotyl.

The epidermis is composed of rather thick-walled cells which are oblong in cross section, the long axis being at right angles to the periphery of the section. These cells are eventually elongated in the tangential direction.

The cortex is very thick. There is no differentiated hypoderma, but three or four of the outer cortical layers are composed of smaller cells than those below.

The endodermis is definite; it is large-celled. In some places it is two layers of cells in thickness. Starch, at first present only in the endodermis, is eventually widely distributed throughout all the parenchymatous tissues.

The stele is cylindrical. There are in the young hypocotyl eight paired xylem bundles and a large number of groups of phloem. The latter soon grow together, forming a complete ring, while the xylem bundles first fuse in pairs, afterward growing together into a closed zone.

In the pericycle, alternating with the paired xylem bundles there are developed four large bands of sclerenchyma which extend so far around that they nearly touch each other. By the end of the first season these become divided into a number of groups by the intercalation of parenchymatous cells.

The pith, which is eventually of slight extent, is composed of large-celled parenchyma.

Cork formation begins rather early the first season in the third or fourth cell layer of the cortex.

Structure of Epicotyl.

The general shape of the epicotyl is originally somewhat hexagonally prismatic; it soon becomes cylindrical.

The cells of the epidermis are originally nearly square in cross section. There are numerous, long, curved, pointed epidermal hairs. The outer two layers of the cortex become slightly collenchymatous. The other cortical layers are composed of parenchyma.

The endodermis was not distinguished in material taken in the autumn but in the young epicotyl is quite distinct. The cells are rather large, similar to those of the cortical region but packed with starch.

The phloem, in youngest material examined, forms a ring of tissue. There are about six principal xylem bundles which soon fuse.

A broken sclerenchymatous ring is formed which resembles that of the epicotyl. No other stereom is, as a rule, produced the first year.

The pith is large and composed of cells with unlignified walls. There is a small-celled perimedullary zone.

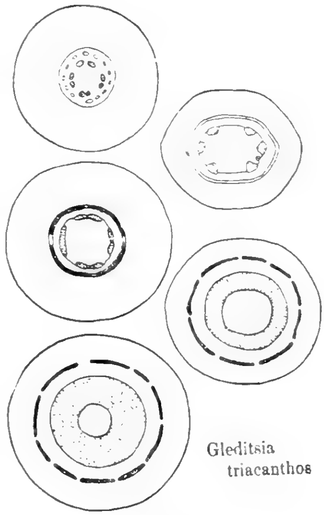
Cork formation takes place in the hypoderma (cf. Moeller [1882], p. 393).

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl differs from the epicotyl in the absence of epidermal hairs and of a collenchymatous hypoderma, in the primary structure of the stele, and in its smaller pith.

In the hypocotyl there are at first four pairs of xylem bundles and a number of phloem bundles. Four large groups of sclerenchyma soon make their appearance in the pericycle. In the epicotyl, on the other hand, a closed ring of phloem surrounds usually about six xylem bundles. No differentiated perimedullary zone was distinguished in the hypocotyl.

The structure of the two regions at the close of the first year differs only in the perimedullary region and pith; the formation of cork having removed the epidermis and hypoderma.



Gleditsia triacanthos

FIG. 10.

PAPILIONACEÆ.

Amorpha fruticosa.

Structure of Hypocotyl.

The epidermis consists of cells rather small, somewhat thick-walled, square or nearly so, in cross section, at length becoming flattened. The cells of the cortex are large; those immediately below the epidermis somewhat smaller, but not forming a definite hypoderma.

The endodermis of thin-walled cells containing starch remains distinct for some time. Toward the close of the first year its exact position cannot be determined, although it can be located approximately. A small amount of starch is scattered throughout the cortex, pith and pericycle as well as the endodermis, even in the youngest stage. This is not the case in most species. Later the phloem and the medullary rays also come to be filled with starch.

The stele is at first quadrangular, and remains so for a considerable length of time. There are four conjoint vascular bundles, and in addition there appear a few small patches of phloem. The bundles soon tend to unite in pairs. Xylem and phloem at length form complete zones. The medullary rays are very numerous; they are one cell in width.

About the time that the epicotyl has reached its full length four small areas of sclerenchyma appear in the pericycle, one adjoining the phloem of each vascular bundle. These increase somewhat in size, and are still visible in two-year-old material. Numerous isolated sclerenchymatous elements are found scattered through the phloem.

The pith is composed of rather large cells with thin walls, which soon become lignified. As the plant grows older the pith becomes almost obliterated. No perimedullary zone was distinguished.

Cork formation takes place in the outer pericycle, at length cutting off all tissues outside, leaving the bundles of sclerenchyma which are at the inner limit of the pericycle.

Structure of Epicotyl.

The epidermis is composed of cells nearly square in cross section. These abut directly upon a large-celled, few-layered cortex. There is no hypoderma.

A definite endodermis was not distinguished at any time although in a very young stage certain starch containing cells were recognized as having the appearance of endodermis; a continuous ring of them was not traced. With the exception of the endodermal and medullary region, starch does not occur until the plant has developed a number of internodes above the epicotyl. The cells of pericycle and phloem are at length filled with starch.

The stele is cylindrical from the first. Owing to fusions the number of vascular bundles is variable. There are, however, generally about five or six bundles. The phloem and xylem eventually form closed rings.

There is a narrow interrupted ring of stereom at the outer edge of the pericycle. Toward the end of the first season numerous small patches of thick-walled fibers appear in the phloem and the pericycle.

The pith is large-celled; it does not decrease appreciably in size as the stem grows older.

In the lower part of the epicotyl cork formation takes place in the pericycle below the ring of stereom mentioned above, thus cutting off the cortex and epidermis which soon die and disappear. In the upper part it takes place in the cortex (cf. Moeller [1882], p. 383). This plant shows a distinct "region tigellaire" in two-year-old material.

Comparison of Structure of Hypocotyl and Epicotyl.

In very young plants the hypocotyl shows a few slightly differentiated layers of smaller cells in the outer cortex. The epicotyl has nothing of the kind.

The endodermis of the hypocotyl is distinct in the early stages, but was not definitely located in the epicotyl. Starch appears earlier in the hypocotyl and the four large groups of stereom are not represented at all in the epicotyl which, however, has an interrupted circle of the same material.

In the former region the stele is at first quadrangular, while always cylindrical in the latter. Cork formation in the hypocotyl is pericyclic, but is cortical in the epicotyl.

The final structure of the two regions is very similar, save in the arrangement of sclerenchyma.

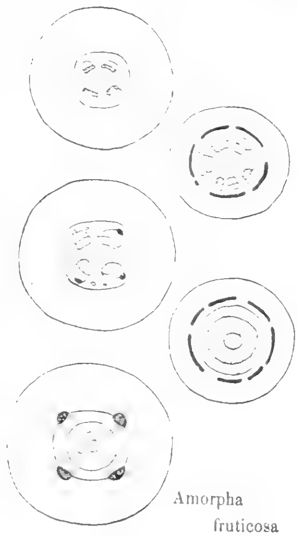


FIG. 11.

Robinia pseudacacia.

Structure of Hypocotyl.

The epidermal cells are oblong in cross section, radially elongated at first, later becoming elongated in the tangential direction. A few straight multicellular hairs are present. There is no differentiated hypoderma. The cells of the cortex are all about the same size.

The endodermis is small-celled and contains starch. It is not easily distinguished in material taken at the close of the growing season. Starch is also found in some of the pericyclic cells in early stages. Later nearly all the parenchymatous tissues have starch.

The stele is originally quadrangular. There are eight phloem bundles and four xylem bundles. These soon produce closed zones.

In the pericycle opposite each of the original xylem bundles a group of stereom appears. These groups, at length, become quite large. In addition to these, at the close of the first year, there are some small patches of stereom irregularly disposed just outside the phloem.

The pith is composed of parenchymatous cells which acquire thick lignified walls. There is a well-differentiated perimedullary zone three or four cells in width. The cells are small and have thick lignified walls.

Cork formation, according to Flot [1890], takes place rather deep in the cortex.

Structure of Epicotyl.

The cells of the epidermis are square or oblong in cross section, and become in time greatly flattened. There are numerous epidermal hairs. A narrow collenchymatous hypoderma is present. The cells of the cortex are about the same size as the epidermal cells.

The endodermis was distinguished only in very young stages. The cells are rather small and closely packed with starch. Starch is found at a later time in the various parenchymatous tissues. Troschel [1879] states that in year-old twigs starch is present in some of the elements of the wood but disappears the next year.

In young material the epicotyl is elliptical in cross section. The stele follows this closely in shape. The phloem forms a closed ring surrounding a variable number of xylem bundles. There are usually more than eight of these bundles. The xylem also soon forms a complete zone in which medullary rays are prominent.

The pith cells become, at length, thick-walled. There is a well-defined perimedullary zone.

Cork arises in the fourth, fifth or sixth layer of the cortex (cf. Moeller [1882], p. 384).

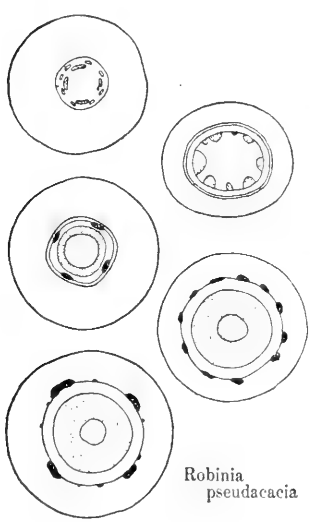


Fig. 12.

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl is without the collenchymatous hypoderma of the epicotyl; it has fewer epidermal hairs; the cortex is thicker; there are four large groups of stereom with some very small ones instead of a broken ring of medium-sized bundles.

In its primary structure the stele of the hypocotyl differs considerably from that of the epicotyl. There are four xylem bundles instead of eight or more and eight phloem bundles instead of a closed ring of phloem.

The cork, although of cortical origin in both regions, arises in the hypocotyl in deeper layers.

RUTACEÆ.

Ptelea trifoliata.

Structure of Hypocotyl.

The cells of the epidermis, when seen in cross section, appear nearly square. They, at length, are flattened. There are a few short, blunt, unicellular hairs. The cortex is large-celled. There is no distinct hypoderma differentiated.

The endodermis is large-celled and contains, at first, very little starch. It later becomes closely packed with starch. The various parenchymatous tissues at length also contain starch in the cell cavities. Numerous lysigenous reservoirs are present in the outer part of the primary cortex.

The stele is originally four-angled. There is one phloem bundle and one xylem bundle in each angle. The phloem soon forms a closed ring surrounding the now greatly enlarged xylem bundles which enclose, at this stage, a somewhat cruciform pith. The xylem bundles also finally fuse.

Four very small groups of sclerenchyma appear, toward the end of the season, in the pericycle. They are equidistant. There are about six cells in each group. Some sections do not show all these groups, as the sclerenchymatous elements do not form continuous strands in the hypocotyl. Some sections show no sclerenchyma at all.

The pith is eventually quite small. The perimedullary zone is not well developed.

The formation of cork begins early in the outermost cortical layer of cells.

Structure of Epicotyl.

The epidermis is composed of cells which appear slightly rectangular in cross section. They are elongated in the tangential direction. Numerous epidermal hairs are present. There is a narrow collenchymatous hypoderma. The cells of the inner cortex are very large.

The endodermis is distinct and can be recognized in year-old material. Starch is present from the first. The various parenchymatous tissues at length have a small amount of starch. Secretion cavities develop in the cortex.

The stele is small; much smaller than is usual in most species. In the youngest material examined the phloem forms a complete ring surrounding a small number of xylem bundles which eventually fuse.

Numerous groups of elements in the pericycle become sclerotic so that they form an interrupted ring of sclerenchyma surrounding the phloem.

The pith is small, unusually so for an epicotyl. There is a definite perimedullary zone of small-celled parenchyma containing starch.

The formation of cork takes place in the outermost layer of hypoderma (cf. Moeller [1882], p. 326).

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl does not have the epidermal hairs and the collenchymatous hypoderma of the epicotyl. The cortex of the former region, though very thick, is but little thicker, in proportion, than that of the epicotyl.

In the stele of the hypocotyl there are four phloem bundles and an equal number of xylem bundles, while in the epicotyl, in the youngest material examined, the phloem forms a closed ring surrounding about six xylem strands.

The sclerenchyma of the hypocotyl is in four somewhat irregular columns in the pericycle, while in the epicotyl it forms more nearly a closed sheath. In the former region also the perimedullary zone is poorly developed.

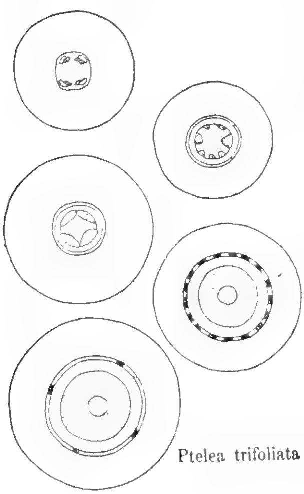


FIG. 13.

SIMARUBACEÆ.

Ailanthus glandulosa.

Structure of Hypocotyl.

The epidermis consists of small cells, square or nearly so, in cross section, and considerably bulged when young. A few short, unicellular hairs were seen, but none noted in very young plants. There is a hypoderma of one or two layers of somewhat larger and thicker-walled cells. The rest of the cortex is parenchymatous and large-celled.

The endodermis consists of cells somewhat smaller than those of the adjacent cortical layer. The endodermis was not recognized in older material. Starch is present from the first in the endodermis, pericycle and pith, but does not appear in the cortex till nearly the close of the first season.

The stele is at first quite small. There are four xylem bundles arranged in pairs and four phloem bundles similarly disposed. The phloem soon forms a complete ring, surrounding the now considerably enlarged xylem bundles, which also eventually form a closed ring.

Opposite each of the four original xylem bundles there appears in the pericycle a group of sclerenchymatous cells. These groups become, at length, somewhat divided so that the old hypocotyl may have a considerable number of smaller groups. There are numerous sclerenchymatous fibers scattered in small and large patches through the phloem and pericycle.

The pith is thin-walled; toward the end of the first season it becomes lignified. The perimedullary zone, described by Flot [1893], as an important feature of the stem structure is first definitely noted at this time.

The oleoresin canals described by Trécul [1867] as occurring at the outer border of the pith, and by Van Tieghem [1884] as in the inner xylem of the stem, were not distinguished in the hypocotyl. Crystal rosettes of calcium oxalate occur singly in certain cells of the phloem area. Single oleoresin cells are found here and there in the cortex and phloem.

Cork formation, as noted by Flot [1889 and 1890] takes place in the layer of cells just below the epidermis.

Structure of Epicotyl.

The epidermis resembles that of the hypocotyl, but there are numerous, somewhat long, curved or hooked epidermal hairs. Most of these are unicellular.

The hypoderma is, as previously described for the stem by De Bary ([1884], p. 404), collenchymatous. The cells are small; toward the inside the hypoderma gradually shades into the ordinary cortex.

A definite endodermis was not distinguished at any stage, although, since starch is present in the region of the pericyle and endodermis from the first, those regions can be located approximately. Starch is found later in pith and cortex; also in many of the inner xylem elements.

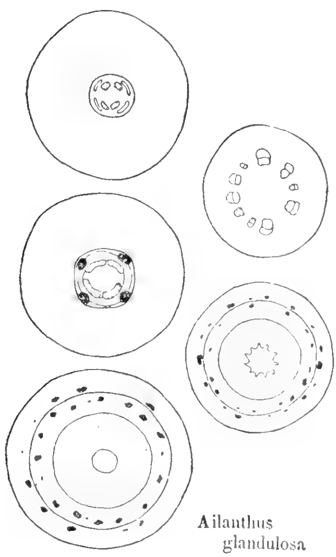
There are, at first, eight to ten conjoint vascular bundles. Eventually the phloem and xylem form closed rings.

Scattered sclerenchymatous elements are found in the phloem, pericycle and cortex.

The pith is irregular in outline. The first formed xylem elements project into it. The perimedullary zone is not conspicuous the first year, being composed of a few cells with unlignified walls.

The cork cambium is formed in the outermost hypodermal layer (cf. Moeller [1882], p. 327).

Comparison of Structure of Hypocotyl and Epicotyl.



Ailanthus glandulosa

FIG. 14.

The hypocotyl has a few, the epicotyl a considerable number, of epidermal hairs. The hypocotyl does not have the collenchymatous hypoderma found in the epicotyl. The pith is smaller and circular instead of scalloped; the perimedullary zone is better developed.

The endodermis is distinct in the hypocotyl for a considerable time, while in the epicotyl it was not definitely distinguished at all. The hypocotyl has, at first, four xylem and four phloem bundles; the epicotyl eight to ten conjoint bundles.

At the close of the year the only differences are those noted in the medullary and perimedullary regions.

ANACARDIACEÆ.

Schinus molle.

Structure of Hypocotyl.

The epidermal cells are square or oblong in cross section, becoming, at length, flattened. There are numerous short epidermal hairs. No hypoderma is developed but the cells of three or four outer layers of the cortex are smaller than those of deeper layers.

The endodermis is small-celled and easily recognized in young stages, although at that time the cells are without starch. Later starch appears in small quantities in these cells and in those of the pith and phloem.

The stele is originally four-angled and remains so for some time. In each angle there is a single xylem bundle and two groups of phloem; these form a crescent-shaped mass bordering a group of cells which later develop into a resin duct. After a time secondary vascular bundles are intercalated between the primary bundles. All finally fuse to produce closed zones of phloem and xylem.

A few small groups of sclerenchymatous cells develop at the outer border of the phloem.

The pith remains somewhat four-sided. The four original xylem bundles project into it at the angles. The pith cells have thin, unlignified walls. A perimedullary zone of small cells was distinguished.

Material old enough to show cork formation was not obtained.

Structure of Epicotyl.

The epidermis resembles that of the hypocotyl. Trichome structures seem to be no more abundant. There is no collenchymatous hypoderma developed. The cells of the cortex are all about the same size.

The endodermis is not easily recognized owing to the fact that in young stages it contains no starch. Later when starch is present the cells have been compressed and displaced by pressure from the subjacent tissues.

The stele contains a variable number of vascular bundles. Usually there are about eight. In connection with each bundle is a small resin passage, at first pointed out by Trécul [1867]. In older material these resin passages become quite large and somewhat flattened. The phloem and xylem then form closed zones.

Groups of sclerenchyma, usually consisting of only a few cells, are found at the periphery of the phloem. These are often located near the resin passages.

The pith is nearly circular, not quadrangular, and is composed of large, thin-walled cells. There is a distinct perimedullary zone.

The region of cork formation was not determined.

Comparison of Structure of Hypocotyl and Epicotyl.

In their primary structure the steles of the hypocotyl and epicotyl show important differences. That of the former region is quadrangular; it has four primary vascular bundles and at a later time other secondary bundles are intercalated. These latter do not have resin canals. In the epicotyl there are about eight vascular bundles each with a resin canal.

The pith of the hypocotyl is four-sided, that of the epicotyl circular in outline, when seen in cross section.

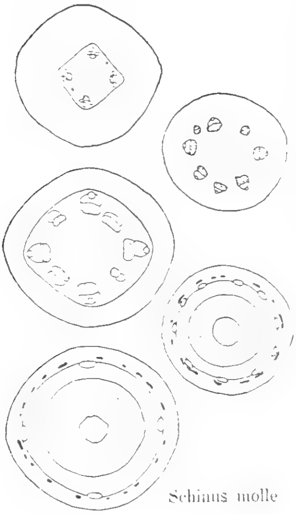


FIG. 15.

RHAMNACEÆ.

Berchemia racemosa.

Structure of Hypocotyl.

The cells of the epidermis are nearly square in cross section, sometimes radially elongated, but becoming at length considerably flattened. No hypoderma is developed, although the cells of the outermost layer of cortical tissue are considerably smaller than those below. There are about five layers of cells in the cortex. This tissue is extremely loose, having many intercellular spaces.

The endodermis is quite distinct until nearly the time that cork formation begins. The cells are smaller than those of the cortex but larger than the pericyclic elements.

Starch is present in the endodermis from the first, but does not appear in the cortex at all, nor in the pith and phloem till about the close of the season.

The stele is originally four-angled. There are four xylem and four phloem bundles. These are paired. They soon fuse so that there are two crescent-shaped bundles, and by further growth closed rings of xylem and phloem are produced.

While the bundles are in the crescent form four small groups of sclerenchyma appear in the pericycle, one opposite each of the original xylem groups.

The pith is composed of large cells, whose thin walls become, at length, somewhat lignified. A perimedullary zone of about two layers may be distinguished but is not always continuous the whole way around the pith.

The cork has its origin in the inner cortex or in the endodermis. Some of the layers of cork carry a brown pigment.

Structure of Epicotyl.

The epidermis, composed originally of small cells, square or pentagonal in cross section, eventually becomes strongly cuticularized and the separate elements very much flattened.

There is no hypoderma developed. The cortex is rather large-celled, but very narrow, being only three or four layers of cells in thickness. During the second year the walls of these cells become conspicuously pitted. Many large crystals, chiefly cubical in form, are found in this region.

The endodermis, composed of flat cells containing starch is distinct till near the close of the first season. Except in the endodermis starch is absent until about the end of the first year's growth, when it appears in the pith and medullary rays.

Even in very young stages the phloem forms a closed zone surrounding a ring of from six to ten, but generally about eight, xylem bundles. These soon become fused. A narrow band of sclerenchyma, for the most part only one cell wide, is found at the outer limit of the phloem; it does not form a closed ring, but is more or less irregular and broken. Small patches of sclerenchyma are found in the phloem of two-year-old seedlings.

The pith is large-celled; the walls are thin but slightly lignified. No perimedullary zone was distinguished.

The region of cork formation was not distinguished. Two-year-old material was examined, but the cork cambium had not begun to form.

Comparison of the Structure of Hypocotyl and Epicotyl.

The epidermis of the hypocotyl remains thinner-walled and exhibits less cuticularization than that of the epicotyl. This is to be expected, since in the former region cork is produced the first year, while in the latter not till a later period.

The hypocotyl has at first four xylem and four phloem bundles, the epicotyl a closed ring of phloem and about eight xylem bundles. In the former area there are but four groups of sclerenchyma, while in the latter there is an interrupted circle of thick-walled elements just outside the phloem.

The pith of the hypocotyl is smaller than that of the epicotyl.

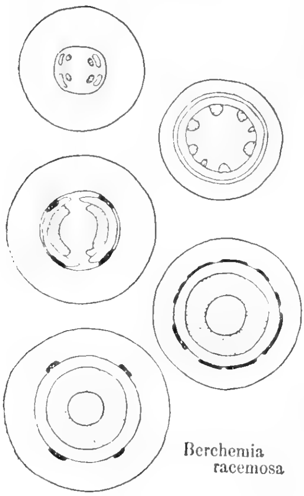


FIG. 16.

Rhamnus purshiana.

Structure of Hypocotyl.

The cells of the epidermis are originally square or pentagonal in cross section. They become, at length, much flattened. The cortex is thick and very large-celled. No hypoderma is differentiated.

The endodermis consists of small, thin-walled cells containing starch. It remains distinct until cork formation takes place. Starch is found, late in the season, in the perimedullary zone and phloem, but not in the cortex.

The stele is originally somewhat four sided and has four vascular bundles which soon fuse and produce closed zones.

The pith is composed of very large cells. The perimedullary zone is rather ill-defined. It is one or two cells in width. The cells are small and contain starch.

The cork is of endodermal origin. Its formation begins toward the close of the growing season.

Structure of Epicotyl.

The epidermal cells, at first square or pentagonal in cross section, become at length, considerably flattened. There are numerous short, curved and pointed hairs. A poorly developed hypoderma is present in year-old material. The cells of the cortex are all about the same size.

The endodermis was distinguished only in young material. The cells are small and contain starch. The perimedullary zone, cortex and phloem have at a later time, small amounts of starch.

The phloem, in the youngest material examined, forms a complete ring. There are about six xylem bundles. These soon fuse.

Considerable masses of stereom develop at the periphery of the phloem forming a broken sheath.

The pith is large-celled. There is present a definite perimedullary zone of small cells containing starch. The cell walls are lignified.

Cork is produced in the outermost hypodermal layer as in other species of *Rhamnus* (cf. Moeller [1882], pp. 292 et seq.).

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl has a thicker cortex than the epicotyl; it does not have a hypoderma; epidermal hairs are absent; the sclerenchymatous ring found in the epicotyl is here absent.

The endodermis of the hypocotyl remains distinct for a greater time than that of the epicotyl. The former region has originally four vascular bundles; the latter has, in the youngest material examined, a zone of phloem and about six xylem bundles. Cork formation in the hypocotyl is endodermal while in the epicotyl it is hypodermal.

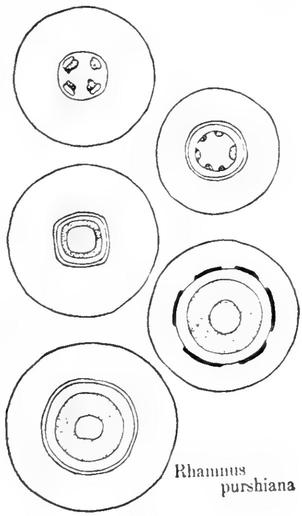


FIG. 17.

VITACEÆ.

Vitis cordifolia.

Structure of Hypocotyl.

The cells of the epidermis are nearly square in cross section, but become at length considerably flattened. Many of them are somewhat prolonged, forming short, blunt papillæ. A thick cuticle is present. In cross section it appears minutely notched.

Three or four of the outer layers of the cortex are small-celled, but not collenchymatous. The cells of deeper layers are larger and all about the same size.

The endodermis is small-celled, and is for a long time readily distinguished because it contains starch. Starch is generally absent from the other tissues, but, at a later time, appears in the pith.

There are four primary vascular bundles. Other secondary bundles soon become intercalated and finally complete rings of phloem and xylem are produced.

A single group of sclerenchymatous elements is formed at the outer edge of each primary vascular bundle. By the end of the season other smaller groups are also present.

The pith finally becomes very small. Sometimes, by the projection into it of two of the vascular bundles, a line of xylem extends nearly across it. There is no perimedullary zone.

The cork cambium, as in other species of *Vitis* (cf. Flot [1889]), is formed about the close of the first season in the pericycle.

Structure of Epicotyl.

The epidermal cells are square in cross section, becoming at length flattened. The cuticle is like that of the hypocotyl. A well-differentiated collenchymatous hypoderma is present. The other cells of the cortex are parenchymatous.

The endodermis contains starch and is, therefore, easily distinguished. Toward the end of the season starch is also found in the pith. The number of primary vascular bundles is variable. Usually there are more than eight. At an early time closed zones of phloem and xylem are produced.

A broken ring of sclerenchyma is developed toward the end of the first year in the pericycle.

The pith is thin-walled and large-celled. A definite perimedullary zone was not distinguished.

The cork, as in the hypocotyl, is of pericyclic origin (cf. Moeller [1882], p. 207).

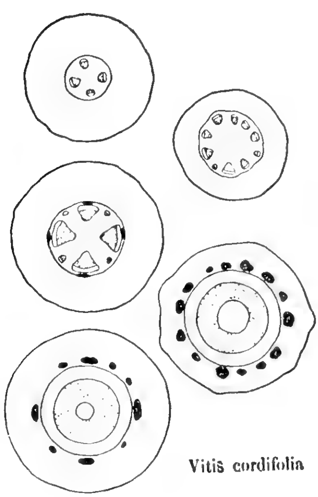


FIG. 18.

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl has a thicker cortex than has the epicotyl. It has but four primary vascular bundles instead of eight or more. It has four large masses of sclerenchyma in the pericycle and a few smaller ones instead of a more nearly continuous sclerenchymatous ring.

The pith of the hypocotyl becomes, at length, nearly obliterated.

ELÆAGNACEÆ.

Elæagnus umbellata.

Structure of Hypocotyl.

The cells of the epidermis are more or less oblong in cross section. There are no epidermal hairs. The outermost layer of the cortex becomes somewhat thick-walled but not collenchymatous. The cortex has about six cell rows.

The endodermis is small-celled. It remains distinct for a time, but in sections of material gathered at the end of the season it was not distinguished. Very little starch is found in any of the tissues save in the endodermis.

The stele is originally four-angled. A single phloem bundle and two xylem bundles are placed in each of the angles. The phloem soon forms a closed ring while the xylem bundles fuse in pairs and increase in size. This leaves a cruciform pith. The continued growth of the xylem produces a complete zone surrounding, at length, a circular pith. Secretion cells in the phloem are numerous.

At the outer edge of the xylem, in old material, are a few patches of sclerenchyma forming a very much interrupted ring.

The pith is of considerable extent and is surrounded by a perimedullary zone of small cells containing starch.

Cork formation takes place far down in the cortex.

Structure of Epicotyl.

The epidermis consists of cells which are oblong in cross section with the tangential about twice the radial diameter even in very young material. The peculiar stellate trichome structures, well known in this genus, are abundant.

The outer cortical cells are nearly circular in outline, when seen in cross section. They are somewhat smaller than the cells of the epidermis. The inner cortex is composed of large cells which eventually are very much flattened owing to pressure of the growing parts within.

The endodermis is small-celled and contains starch. In old material it was not recognized.

The stele is circular from the first. In the youngest material examined the phloem forms a complete ring surrounding about six xylem groups. The xylem bundles soon fuse producing at the end of the season quite a thick zone.

An interrupted sclerenchymatous ring is developed in the pericycle.

The pith, which is composed of large thin-walled elements, is surrounded by a narrow small-celled perimedullary zone containing starch.

The cork is formed rather late in the season in the outermost cortical layer as in other species of *Elaeagnus* (cf. Moeller [1882], p. 117).

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl is without the trichome structures so noticeable in the epicotyl; the stele is at first four-angled instead of cylindrical; there are four phloem bundles and eight xylem bundles instead of a ring of phloem and six xylem bundles.

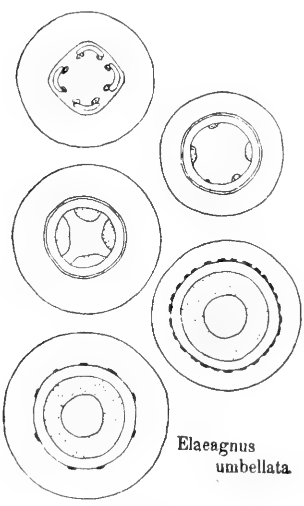


FIG. 19.

At the end of the season the vascular tissue is alike in the two regions but the pericyclic sclerenchyma of the hypocotyl is less abundant. Cork is developed in the inner cortex of the hypocotyl and in the outermost layer of cortex in the epicotyl.

MYRTACEÆ.

Eucalyptus globulus.

Structure of Hypocotyl.

The epidermal cells, at first oblong, radially elongated, become at length in cross section nearly square. The cuticle, which is covered with elevations, appears, when young, in cross section minutely serrate.

There is no hypoderma differentiated, but the outermost layer of the cortex is smaller-celled than the layers below. The cortical cells are large. They become flattened toward the end of the season by the growth of the internal tissues.

The endodermis is composed of small cells containing starch; it at length becomes indistinguishable. Starch is for the most part absent from other tissues. Lysigenous secretion reservoirs are found in the conjunctive tissue.

The stele is four-sided. The general shape of the hypocotyl sometimes follows that of the stele (cf. Irmisch [1876]). There are originally four narrow curved phloem bundles and the same number of small xylem bundles. The phloem soon forms a closed ring; the xylem bundles increase in size, leaving for a time a cruciform pith; but eventually the xylem also forms a complete ring and the pith is cylindrical.

Four small groups of sclerotic cells make their appearance in the pericycle about the time that the phloem ring is first formed. These groups eventually become somewhat broken up and numerous groups of fibers appear in the phloem arranged in three or more interrupted circles.

The pith is large-celled. It is small in amount even from the first. No definite perimedullary zone was distinguished.

Cork formation, according to Flot [1890], is cortical or pericyclic.

Structure of Epicotyl.

The cells of the epidermis are at first more nearly square in cross section than those of the hypocotyl. They at length become very much elongated in a tangential direction.

The cortex is large-celled; the cells of the outer layer are rather small. No hypoderma is differentiated. Numerous lysigenous secretion sacs are present.

The endodermis is thin-walled; the cells are small and contain starch.

The stele is at first somewhat quadrangular and becomes at length elliptical, in cross section. In the youngest material examined the phloem forms a closed ring. The number of xylem bundles is somewhat variable; these are so disposed that the pith is generally at first somewhat cruciform.

The pericycle becomes, at length, largely sclerenchymatous; numerous interrupted rings of bast fibers begin to appear but are only slightly thickened the first year.

The pith, at first cruciform, becomes somewhat quadrangular. There is a perimedullary zone (*fide* Flot [1893]). An internal cambium produces a ring of phloem just outside the pith. This is mentioned by DeBary [1884]. A few sclerotic cells were noted at the inner limit of the internal phloem.

According to Flot [1890] cork formation is sub-epidermal.

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl is more nearly cylindrical than the epicotyl; its epidermis less flat, its stereom is better developed the first year. Stem internodes above the epicotyl are square.

The primary structure of the hypocotyl is like that of *Tecoma*. There are four xylem bundles and four phloem bundles. In the youngest epicotyl examined the phloem forms a complete ring and there is a variable number of xylem bundles.

No internal phloem was recognized in the hypocotyl although it is quite distinct in the epicotyl. The cork of the former region is pericyclic or cortical in origin, that of the latter subepidermal.

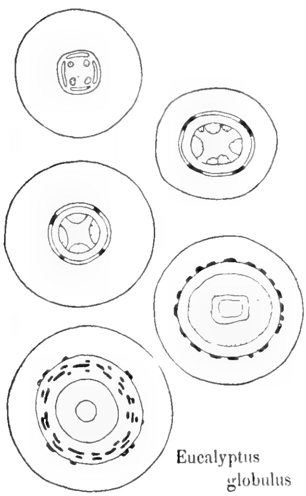


FIG. 20.

BIGNONIACEÆ.

Tecoma radicans.

Structure of Hypocotyl.

The epidermal cells are rectangular in outline when seen in cross section. From being originally radially elongated they are, at length, nearly square. The cuticle in cross section appears minutely serrate. There are a few short, simple, epidermal hairs.

The cortex is of loose parenchyma, generally about six layers in thickness. There is no differentiated hypoderma.

The endodermal cells are smaller than the cells of the cortex. Originally they are irregularly hexagonal in outline, but toward the end of the year they become elliptical and have slightly thickened walls. Starch is entirely absent, except in the endodermal region until nearly the close of the first year, when it appears especially in the pith.

The stele is originally very small and somewhat four-sided, containing four xylem bundles and four phloem bundles. The latter are next the pericycle. They alternate with the xylem bundles. These are presumably the four "principal bundles" found, according to Hovelacque [1888], in all Bignoniaceous stems. At quite an early stage the phloem and xylem form closed rings.

About the time that this is apparent four small groups of sclerenchyma make their appearance in the pericycle just outside the original xylem bundles. Each of these is composed of only six to ten cells with extremely thick walls. Later numerous isolated, lignified sclerenchymatous cells appear in the outermost layer of the cortex; a few also are found in the phloem area.

The pith is large-celled and thin-walled. The formation of a cambium layer in the small-celled perimedullary region begins some time before the close of the year. This will be further noticed in the description of the epicotyl.

Cork formation takes place in the second cortical layer, *i. e.*, in the cell layer immediately below the sclerenchyma which is thus eventually lost.

Structure of Epicotyl.

The epidermis has a well-marked cuticle which, in cross section, appears minutely notched. The cells seen in cross section are about square, but become tangentially elongated toward the end of the season. There are occasional short epidermal hairs.

The cells of the outermost layer of the cortex are somewhat smaller than those of deeper layers. These are considerably flattened. Although at first of about even thickness throughout, the cortex soon grows in thickness at four equidistant points giving the epicotyl a quadrangular prismatic shape.

The endodermis, which in young stages is distinct, at length becomes indistinguishable owing to displacement and crowding of the cells caused by growth in the lower layers. Starch, though present in the endodermal region, is found only in very small amount in the cortex and pith until the close of the season. Even then the cells are not closely packed with it.

Even in the youngest stage examined, *i. e.*, second stage of our arbitrary division, the phloem and xylem form complete rings.

The outermost cortical layer toward the end of the season becomes largely sclerenchymatous, although here and there are cells with but slightly thickened walls. Certain cells of the pericycle, at first but slightly differentiated, form, at length, groups of very thick-walled cells.

The pith is composed of large cells with thin, unlignified walls. It is found to be practically in the center of the section, though Pedicino [1876] found that when the plant climbs the pith is eccentric. About the time that the seedling has developed one internode above the epicotyl a medullary cambium has begun to form in the epicotyl. This produces xylem without and phloem next the pith. Considerable masses of phloem may thus be formed. This peculiar cambium in *Tecoma* was noted by Sanio in 1864 and fully described later by De Bary [1884]. Young branches of the plant were studied by these investigators who did not examine seedlings.

Cork formation, as previously described by Moeller [1882] for young branches, takes place in the second layer of the cortex. The cork cells are nearly square in cross section.

Comparison of the Structure of Hypocotyl and Epicotyl.

Although both hypocotyl and epicotyl are originally cylindrical, only the former remains so, the latter developing four thickened areas which make it somewhat quadrangular.

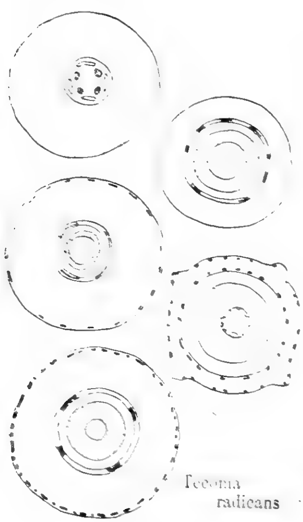


FIG. 21.

The four small groups of sclerenchyma in the pericycle of the hypocotyl are represented in the other region by a considerable number of smaller groups forming an interrupted ring. The endodermis remains distinct in the hypocotyl for a longer time than in the epicotyl. The medullary cambium is formed later and is less active.

Catalpa speciosa.

Structure of Hypocotyl.

The epidermis consists of small cells, square in cross section. Short, blunt epidermal hairs are rather numerous. No hypoderma is developed; all the cortical cells are thin-walled.

The endodermis remains distinct for a long time. It consists of thin-walled cells which are but slightly smaller than the cells of the cortex. Starch is present, from the first, in the endodermis and toward the close of the season appears sparingly distributed in medullary rays and cortex; it is apparently absent from the pith.

The stele is small; in cross section it is circular. There are at first six, seven or eight conjoint vascular bundles arranged in a circle. Eight is probably the original number, but fusions often take place between adjoining bundles. Complete zones of xylem and phloem are formed at an early stage. About this time four small groups of sclerenchyma appear in the pericycle; they are equidistant. These eventually become somewhat divided, and other cells of the pericycle become sclerotic, so that a number of small groups of stereom are found in this area.

The pith is small in amount. The cells are large, with thin, slightly lignified walls. There is a perimedullary zone of small cells containing starch.

Cork formation takes place in the outermost layer of cortical cells.

Structure of Epicotyl.

The epidermal cells at first are oblong in cross section; the long axis is at right angles to the periphery of the section. Later the shape is more nearly square. There are many straight, blunt epidermal hairs.

The first two or three cell layers of the cortex are collenchymatous. The other layers are rather small-celled parenchyma.

The endodermis, though at first distinct on account of the presence of starch in its cells, was not recognized in older material. Starch is absent from the other tissues in the early stages, but is at length found in the cortex, phloem, medullary rays and perimedullary zone.

Toward the end of the first year a narrow, much interrupted ring of sclerenchyma appears at the outer edge of the phloem. The cells are small with very narrow lumen.

The number of vascular bundles is somewhat variable. About twenty is the usual number. These soon unite to form zones of xylem and phloem.

The pith is large, the cells thin-walled parenchyma. There is a perimedullary zone of small cells containing starch.

Cork arises in the outermost hypodermal layer, as it does in the stem of *Catalpa catalpa* (cf. Moeller [1882], p. 184).

Comparison of Structure of Hypocotyl and Epicotyl.

The epidermis of the hypocotyl has fewer and shorter hairs than that of the epicotyl. The former region has no hypoderma, though in the epicotyl a distinct collenchymatous zone is developed.

The endodermis of the hypocotyl remains distinct for a much longer time than that of the epicotyl; the stele has about eight vascular bundles, instead of twenty or more; sclerenchyma is first disposed in four groups instead of a considerable number.

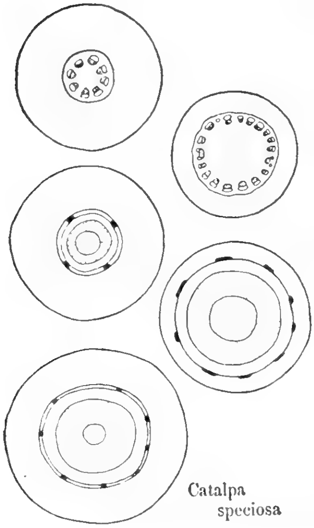


FIG. 22.

The pith of the hypocotyl is much smaller in amount than that of the epicotyl.

RUBIACEÆ.

Cephalanthus occidentalis.

Structure of Hypocotyl.

The cells of the epidermis are oblong or somewhat hexagonal in cross section. About every fifth or sixth cell is elongated radially and pointed, projecting somewhat beyond the general line of cells. These might be described as extremely short hairs. This characteristic feature continues for a considerable length of time.

No distinct hypoderma is formed. The cells of the two or three outer layers of the cortex are rather thick-walled but not collenchymatous. The cortex is loose with numerous large intercellular spaces.

The endodermis is large-celled. It remains distinct through the first year although the cells become at length very much flattened. They contain starch. Starch is later found in the various parenchymatous tissues.

The stele is circular in cross section. There are originally four phloem bundles and an equal number of xylem bundles; they are grouped in pairs. The xylem and phloem soon form closed zones, the xylem encroaching upon the pith which, at the close of the first season is almost entirely obliterated. The hypocotyl thus assumes a root-like structure—"rhizelle" of Van Tieghem [1891].

The cork is of epidermal origin.

Structure of Epicotyl.

The epidermal cells are rectangular in cross section. The radial is the long diameter at first but eventually the two diameters are nearly equal. Many of the cells are prolonged to form pointed hairs which are about three times as long as the ordinary cells of the epidermis.

A narrow collenchymatous hypoderma is developed; this shades off gradually into the ordinary cortex, which is quite extensive.

The endodermis is rather large-celled, the cells resembling those of the cortex but containing starch. The endodermis remains distinct throughout the first year. Starch, which is at first absent from the other tissues, becomes, at length, distributed through all the parenchymatous elements.

The stele, originally elliptical in cross section, follows the general shape of the epicotyl. Eventually the epicotyl becomes cylindrical as does also the stele. In the youngest material examined, the phloem forms a complete zone surrounding a ring of about six xylem bundles, which soon fuse to form a closed ring.

A few of the cells of the pericycle become sclerotic after a time. These are generally isolated; not aggregated in groups.

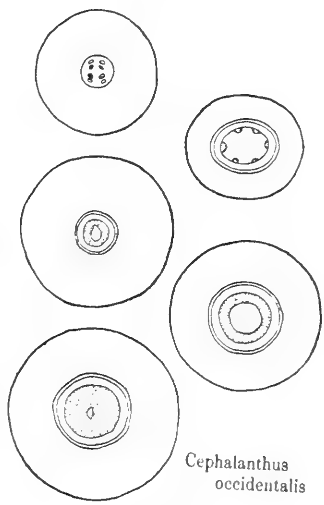
The pith becomes quite small; it is surrounded by a well-developed small-celled perimedullary zone whose elements contain starch.

The cork, like that of the hypocotyl, arises in the epidermis.

Comparison of Structure of Hypocotyl and Epicotyl.

The hypocotyl differs from the epicotyl in its shorter epidermal hairs, in the absence of a true hypoderma and in the much looser parenchyma of its cortex.

The structure of the stele is also very different, the hypocotyl having originally four phloem bundles and four xylem bundles, while in the epicotyl the phloem, even in the youngest



Cephalanthus occidentalis

FIG. 23.

stage examined, forms a closed ring surrounding six xylem bundles.

At the end of the first year the structure of the two regions is essentially the same except that the hypocotyl is without pith or differentiated hypoderma.

GENERAL CONCLUSIONS.

The following summary and conclusions are based on the facts shown in the foregoing pages. It is not intended to repeat here all the points which are there given, but merely to bring together under appropriate headings the most important facts of structure of the hypocotyl and epicotyl in the plants studied.

General Shape of Hypocotyl and Epicotyl.—In cross section the hypocotyl is usually circular in outline, the epicotyl is, however, not infrequently hexagonal in outline and somewhat flattened. The hypocotyl has usually in early stages much the greater diameter.

Comparison of the Epidermis of Hypocotyl and Epicotyl.—The epidermal cells of both regions when seen in cross section appear at first square or radially elongated. After a time, however, they became elongated tangentially, being stretched by the growth of the stelar tissues and not continuing to divide. In quite young stages some plants have in the epicotyledonary region, epidermal cells which, in cross section, appear tangentially elongated, viz.: *Ulmus americana*, *Liriodendron tulipifera*, *Butneria florida*, *Cercis canadensis*. Trichome structures are usually fewer and less complex in the hypocotyledonary region, *e. g.*, *Ulmus americana*, *Broussonetia papyrifera*, *Butneria florida*, *Robinia pseudacacia*, *Ailanthus glandulosa*, *Catalpa speciosa*, *Cephalanthus occidentalis*. In the following species the epicotyl has trichome structures but they are absent from the hypocotyl: *Celtis occidentalis*, *Toxylon pomiferum*, *Gleditsia triacanthos*, *Ptelea trifoliata*, *Rhamnus purshiana*, *Elæagnus umbellata*, *Tecoma radicans*.

Hypoderma in the Hypocotyl and Epicotyl.—Only one of the species examined has a definite collenchymatous hypoderma in both regions. This is *Butneria florida*. The following plants have a hypoderma in the epicotyl, but not in the hypocotyl: *Celtis* *occidentalis, Broussonetia papyrifera, Liriodendron tulipifera, Menispermum canadense, Gleditsia triacanthos, Robinia pseudacacia, Ptelea trifoliata, Ailanthus glandulosa, Rhamnus purshiana, Catalpa speciosa, Cephalanthus occidentalis.*

Comparison of Cortex of Hypocotyl and Epicotyl.—The cortical cells of the hypocotyl are nearly always much larger than those of the epicotyl. This is so commonly the case that various species need not here be specially mentioned; a good example is *Parkinsonia aculeata.* The cortex of the hypocotyl is thicker than that of the epicotyl.

Comparison of Endodermis and Pericycle in Hypocotyl and Epicotyl.—The endodermis in the hypocotyl is, as a rule, more distinct and persists longer than that of the epicotyl. Its cells contain starch. Pericycle is well developed in the hypocotyl, usually consisting of two or more layers of small cells.

Typical Structure of the Stele of the Hypocotyl. The stele is usually somewhat quadrangular. As a rule there are four phloem bundles and four xylem bundles. The phloem and xylem may be in contact or they may be separated by a small amount of undifferentiated parenchyma. In the latter case each phloem area is either directly outside of a xylem area (when the phloem may be spoken of as opposite the xylem), or the phloem bundles are removed from the xylem by greater or less angular distances (alternate arrangement). Using the foregoing terminology the arrangement of bundles may be described as opposite in the following: *Liriodendron tulipifera, Menispermum canadense, Butneria florida, Cercis canadensis, Amorpha fruticosa, Ptelea trifoliata, Ailanthus glandulosa, Schinus molle, Berchemia racemosa, Rhamnus purshiana, Vitis cordifolia, Cephalanthus occidentalis.* It is alternate in *Eucalyptus globulus* and *Tecoma radicans.*

Certain modifications of the more usual type just described would best be noted separately. There are four xylem bundles and eight phloem bundles in *Robinia pseudacacia.* In *Parkinsonia aculeata, Gleditsia triacanthos* and *Elæagnus umbellata* there are eight xylem bundles and four phloem bundles. The xylem bundles soon fuse together in pairs in the last two named species. In *Celtis occidentalis* and *Toxylon pomiferum,* the phloem forms two crescent-shaped areas while the arrangement of the xylem is normal.

Unusual Structure of the Stele of the Hypocotyl.—In certain species the stele of the hypocotyl does not have the typical structure just mentioned, the number and arrangement of vascular bundles being different. *Ulmus americana* has two xylem crescents and numerous small phloem bundles; *Broussonetia papyrifera* has a root-like structure; in *Catalpa speciosa* there are about eight vascular bundles.

Primary Structure of the Stele of the Epicotyl.—In shape the stele of the epicotyl is often originally somewhat hexagonal, though, as in the case of the hypocotyl, becoming at length cylindrical. As is well known there are usually from six to very many vascular bundles. Sometimes the phloem is completely fused into a closed zone even in very young stages.

Arrangement of Sclerenchyma in the Hypocotyl. The sclerenchyma of the hypocotyl first appears as four masses in the pericycle in *Toxlyon pomiferum*, *Liriodendron tulipifera*, *Cercis canadensis*, *Gleditsia triacanthos*, *Robinia pseudacacia*, *Ailanthus glandulosa*, *Vitis cordifolia*, *Eucalyptus globulus*, *Tecoma radicans* and *Catalpa speciosa*. In the plants just named this original disposition of the sclerenchyma becomes altered either by the intercalation of parenchymatous elements in the areas of sclerenchyma or by the development of sclerenchyma at other points. In the following plants, however, there is practically no change in the sclerenchyma during the first year and the four original masses remain to the end of the season: *Parkinsonia aculeata*, *Amorpha fruticosa*, *Ptelca trifoliata*, *Berchemia racemosa*.

Comparison of the Hypocotyl and Epicotyl with Reference to the Distribution of Sclerenchyma. Commonly the sclerenchyma in the two regions becomes, at the close of the first growing season, equally well developed and similarly arranged. Exceptions to this rule will now be noted. Sclerenchyma is absent from the hypocotyl of *Menispermum canadense*, *Butneria florida* and *Rhamnus purshiana* although present in the epicotyl. In *Ptelea trifoliata* and *Berchemia racemosa* at the close of the first year there is a greater development of sclerenchyma in the epicotyl than in the hypocotyl. The reverse of this condition obtains in *Celtis occidentalis* and *Eucalyptus globulus*. Only scattered sclerenchyma in small amount was recognized in either region in year-old material of *Broussonetia papyrifera;* in *Cephalanthus occidentalis* a few only of the pericyclic cells of the epicotyl become sclerotic.

Cork Formation in Hypocotyl and Epicotyl. The cork cambium is developed in the layer of cells next below the epidermis in both hypocotyl and epicotyl of *Celtis occidentalis*, *Liriodendron tulipifera*, *Butneria florida*, *Ptelea trifoliata*, *Ailanthus glandulosa*, *Catalpa speciosa*. In *Cephalanthus occidentalis* it is of epidermal origin in both regions. In the following species cork formation is sub-epidermal in the epicotyl but the cork is produced in deeper cell layers of the hypocotyl: *Ulmus americana*, *Toxylon pomiferum*, *Broussonetia papyrifera*, *Rhamnus purshiana*, *Elæagnus umbellata*, *Eucalyptus globulus*. In *Cercis canadensis*, *Gleditsia triacanthos*, *Amorpha fruticosa*, *Robinia pseudacacia*, *Vitis cordifolia* and *Tecoma radicans* cork formation in the epicotyl is cortical, while in the hypocotyl it takes place in some cases in the same cell layer, in other cases in deeper layers. Details are given in the previous descriptions for the separate species.

Pith and Perimedullary Zone of Hypocotyl and Epicotyl. The pith of the hypocotyl is smaller than that of the epicotyl, sometimes it becomes nearly obliterated, *e. g.*, *Cephalanthus occidentalis*. The perimedullary zone is sometimes not distinguished in the hypocotyl though present in the epicotyl, *e. g.*, *Parkinsonia aculeata*, *Gleditsia triacanthos*, *Eucalyptus globulus*. The opposite condition is found in *Cercis canadensis* and *Berchemia racemosa*. More often where a perimedullary zone is recognized it is equally developed in both hypocotyl and epicotyl.

Structure of Hypocotyl and Epicotyl at the close of the first year's growth.—Owing to secondary changes the two regions, though at first quite dissimilar in structure, may come to be very much alike. The xylem and phloem always form closed rings; the endodermis often becomes indistinguishable; the cells of the cortex become flattened. The differences of pith, perimedullary zone and sclerenchyma have already been given.

Condensed Summary.

Although secondary changes may cause a great resemblance in the structure of hypocotyl and epicotyl, the two regions are, in their primary structure, essentially dissimilar.

The epidermis of the hypocotyl is more often without trichome structures, the cortex is thicker and composed of larger cells, the endodermis is more distinct and persists for a greater length of time, the pith is smaller, sclerenchyma is often less well-developed and differently arranged and a hypoderma, so common in the epicotyl, is nearly always absent. Cork formation in the hypocotyl begins either in the same cell-layer that it does in the epicotyl or in a deeper layer, never in a more superficial one.

Starch is, as a rule, distributed in the same way in both regions. It is usually present in the endodermis in the early stages but does not appear in other tissues until the plant has developed foliage leaves, in considerable number.

As to the structure of the stele it may be said that in the hypocotyl there are usually four primary vascular bundles. The exact disposition of the phloem and xylem elements is subject to some variation. Occasionally there are more than four bundles. In the epicotyl the vascular bundles are from six to eight or very many.

The hypocotyl does not have a root-like structure.

Explanation of Plates.

Plate V. Drawings of cross sections to show the primary stelar structure of the hypocotyl of *Ulmus americana*, *Celtis occidentalis*, *Toxylon pomiferum* and *Broussonetia papyrifera*.

Plate VI. Drawings of cross sections to show the primary stelar structure of the hypocotyl of *Menispermum canadense*, *Butneria florida*, *Amorpha fruticosa*, *Robinia pseudacacia* and *Ptelea trifoliata*.

Plate VII. Drawings of cross sections to show the primary stelar structure of the hypocotyl of *Ailanthus glandulosa*, *Schinus molle*, *Berchemia racemosa*, *Eucalyptus globulus*, *Catalpa speciosa* and *Cephalanthus occidentalis*.

Plate VIII. Photographs of cross sections to show the primary structure of the hypocotyl. 1. *Ulmus americana*, 2. *Liriodendron tulipifera*, 3. *Parkinsonia aculeata*, 4. *Cercis canadensis*, 5. *Berchemia racemosa*, 6. *Vitis cordifolia*, 7. *Eucalyptus globulus*, 8. *Tecoma radicans*.

The drawings were all outlined with the aid of a camera lucida. The magnification used was about five hundred diameters. For publication the drawings have been reduced to one-half their original size. The magnification used in making the photographs was from fifty to eighty diameters. They have been slightly reduced. All drawings and photographs were made by the author from his own preparations.

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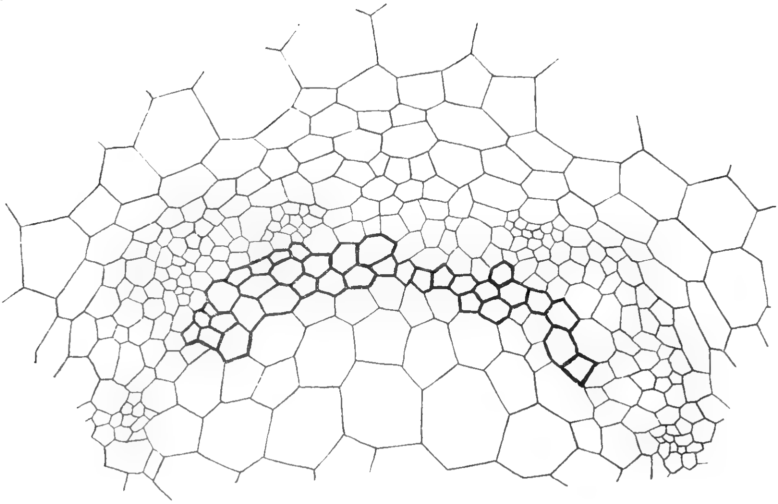

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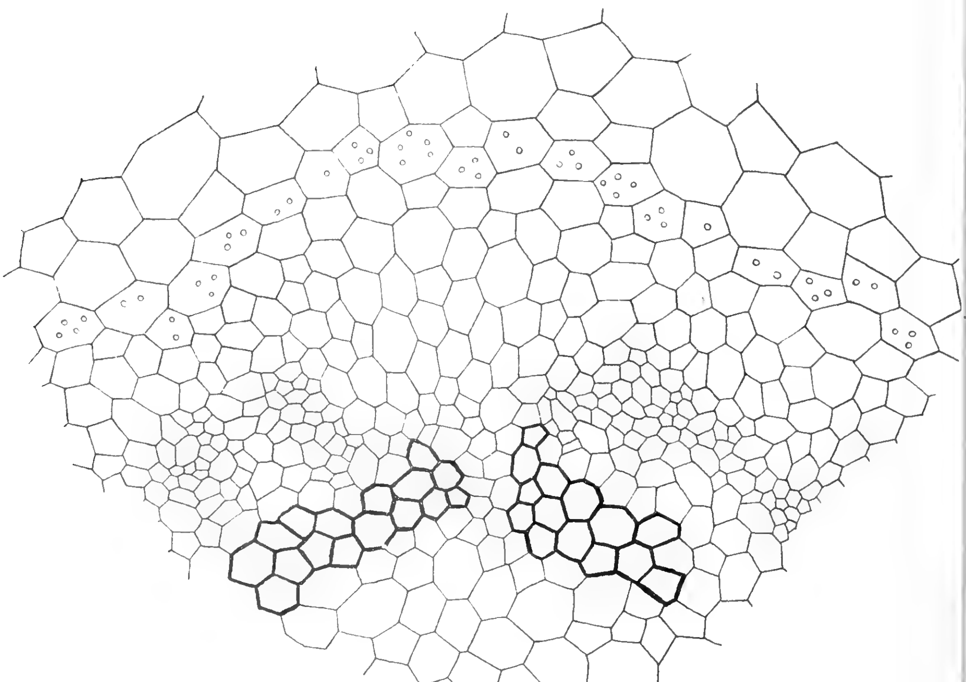

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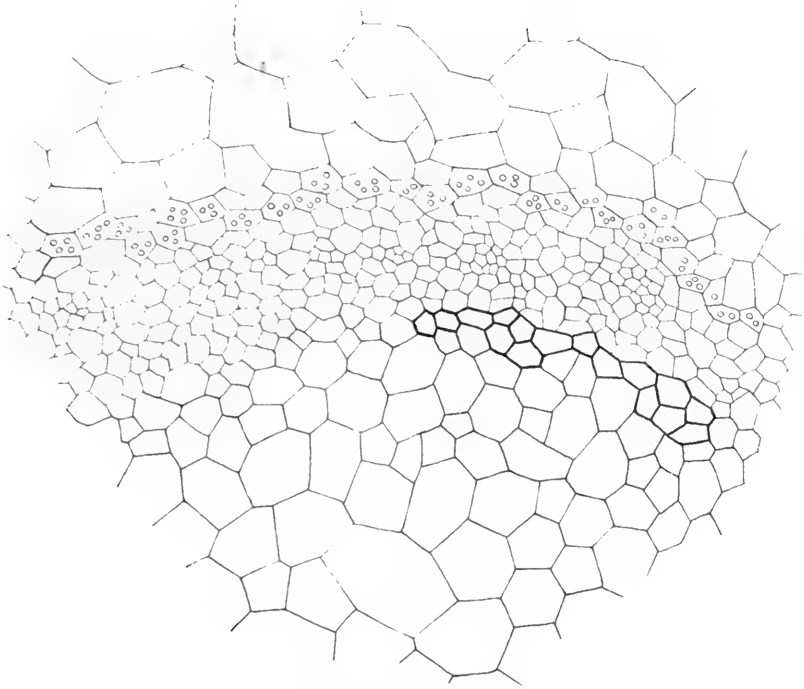

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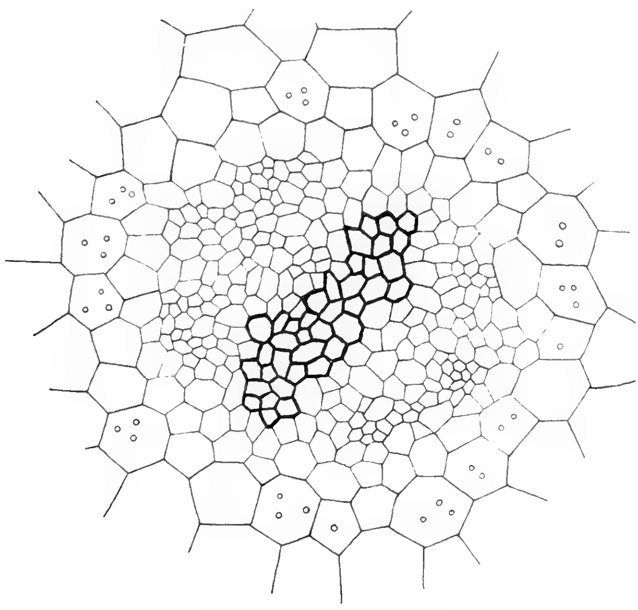

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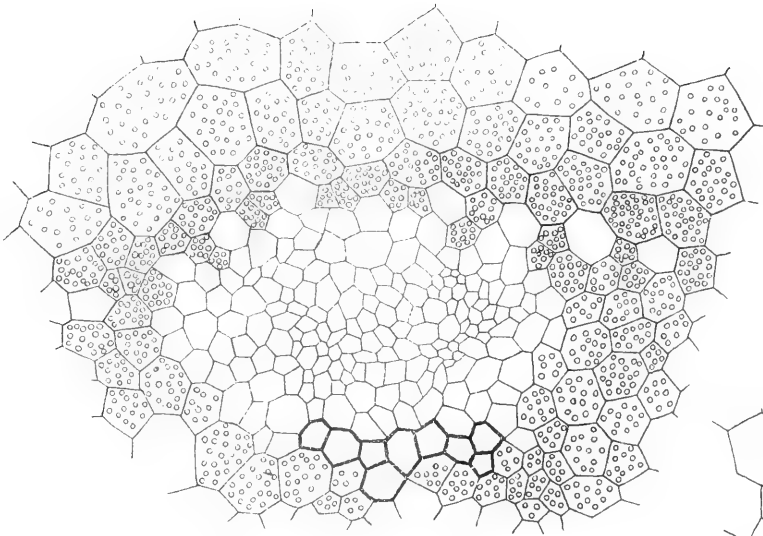

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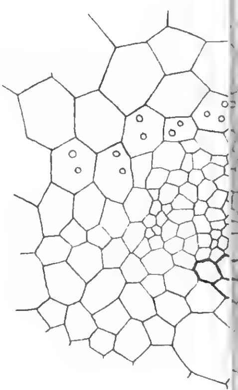
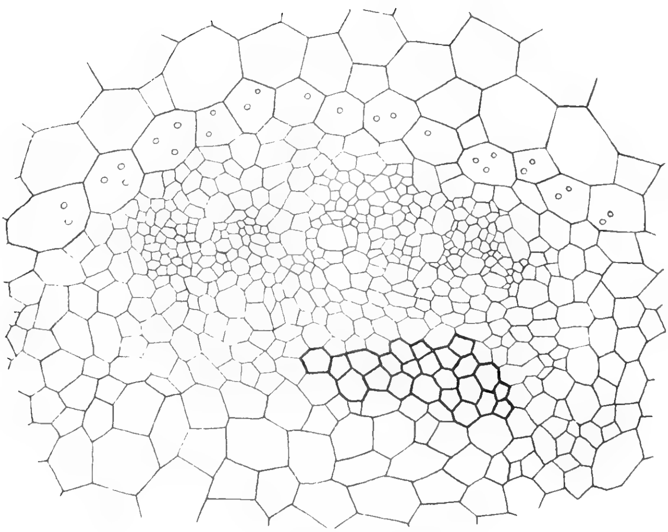


Amorpha



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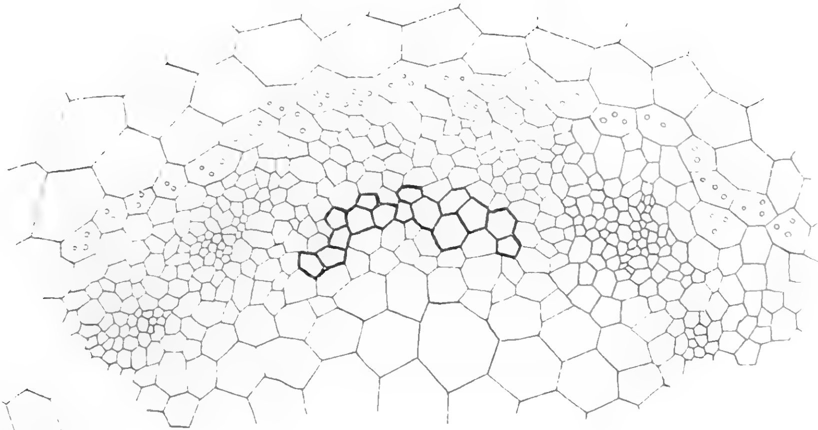

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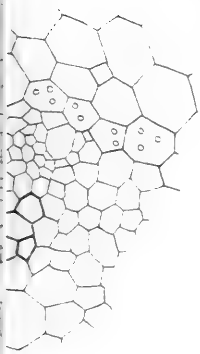

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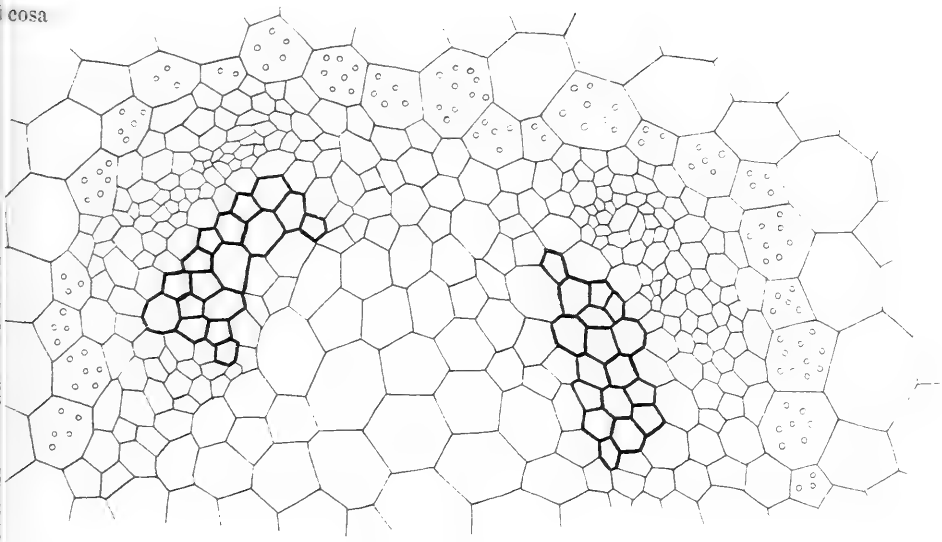
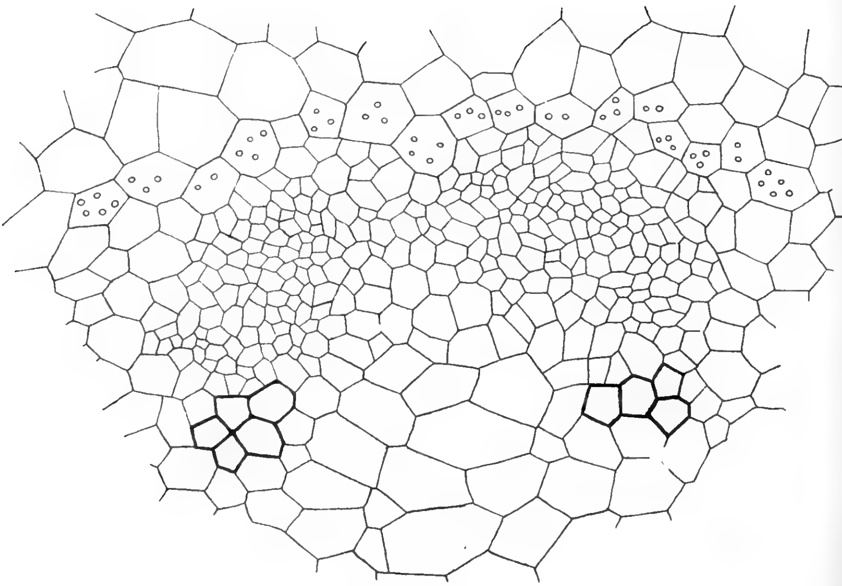
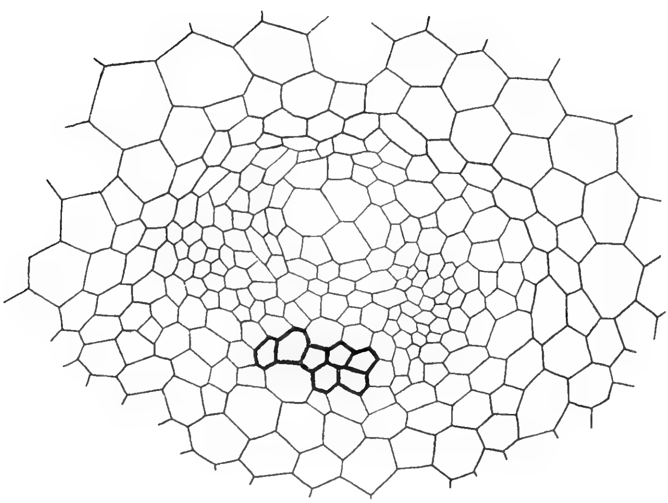


Ptelea trifoliata

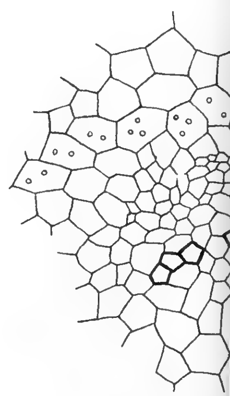
E VI.



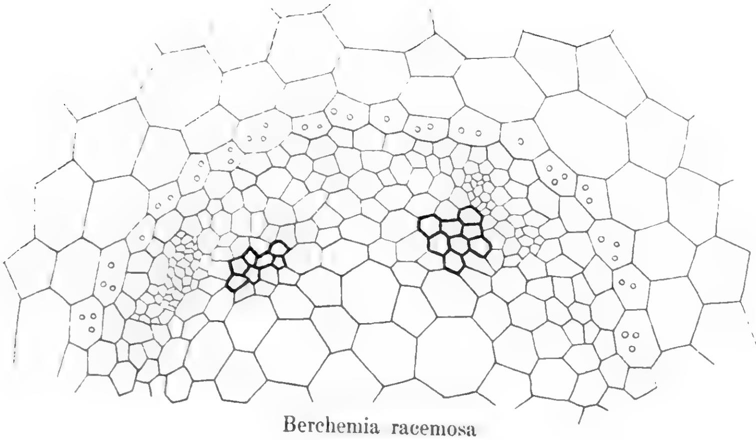
Ailanthus glandulosa



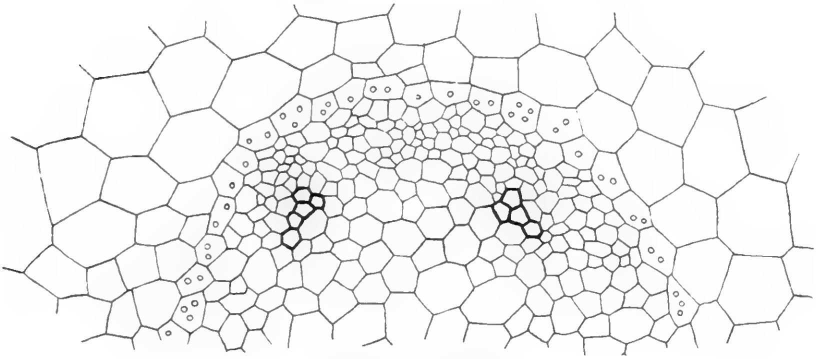
Schinus molle



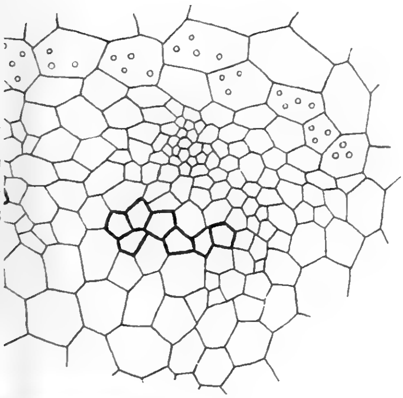
HELIOTYPE



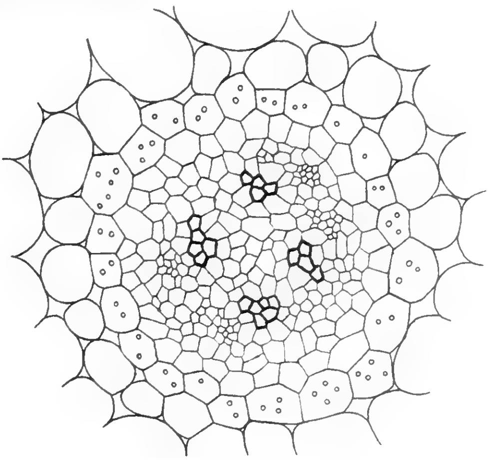
Berchemia racemosa



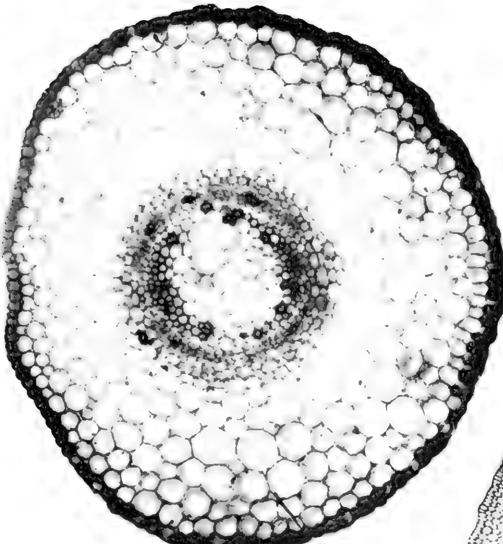
Eucalyptus globulus

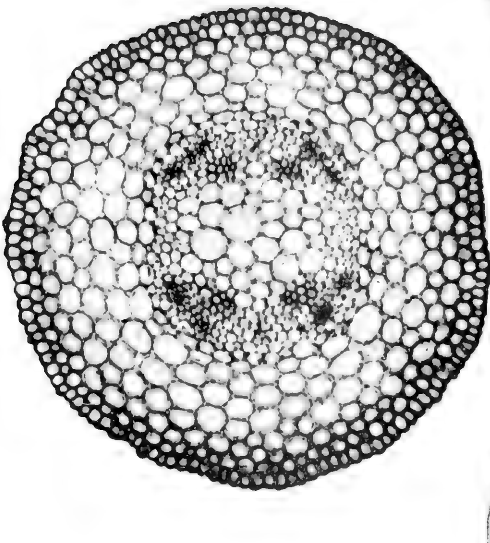


talpa speciosa



Cephalanthus occidentalis

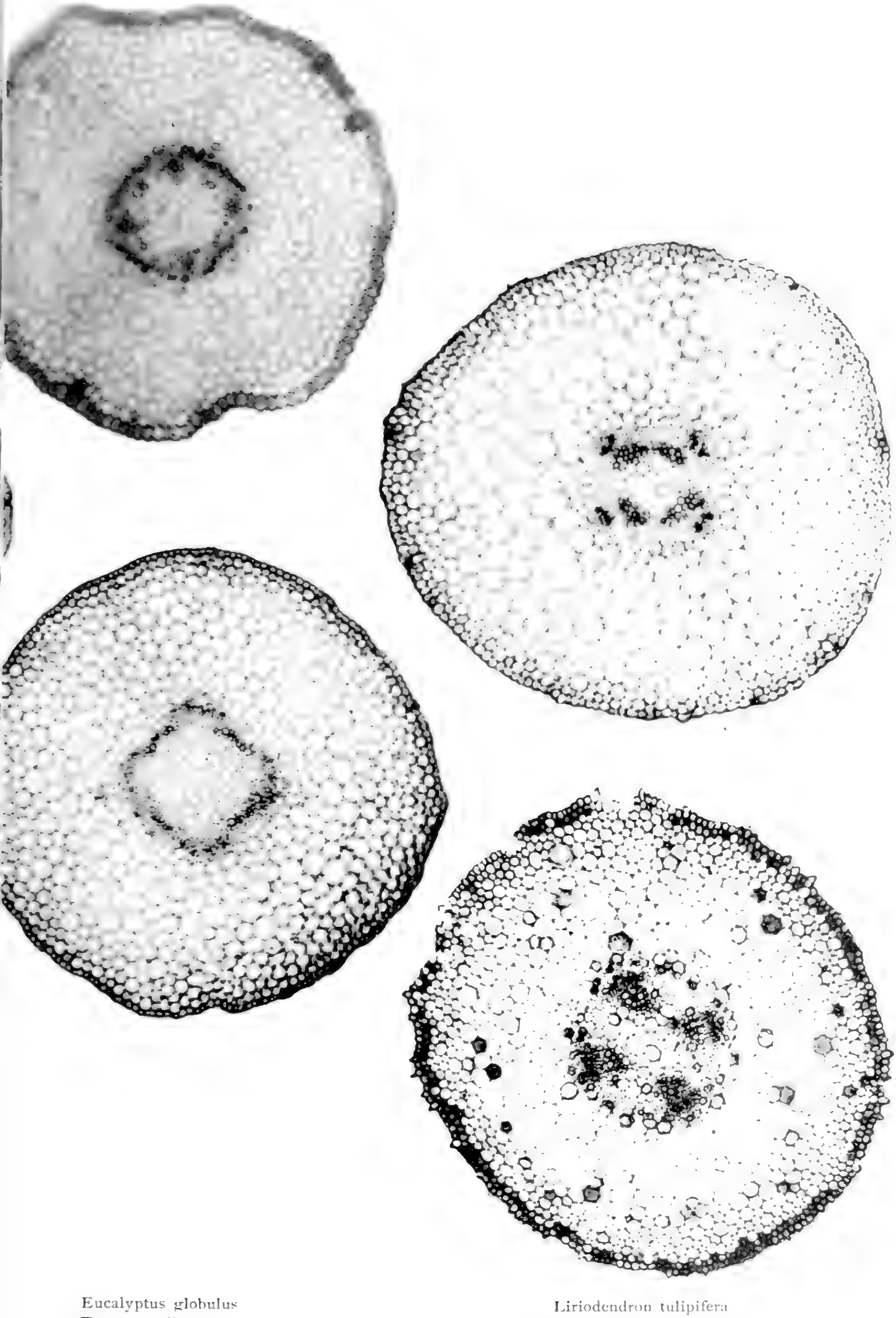




Ulmus americana
Berchemia racemosa

Parkinsonia aculeata
Cercio canadensis

THE HELIOTYP



Eucalyptus globulus
Tecoma radicans

Liriodendron tulipifera
Vitis cordifolia

VIII.

ING CO BOSTON

X. CONTRIBUTION TO THE LIFE-HISTORY OF RUMEX.

BRUCE FINK.

Introduction.—The preliminary work leading to the present paper was nearly all done in the botanical laboratories of the University of Minnesota during the summers of 1896 and 1897. This work included a study of the macrosporangia and their contents in *Bursa bursa-pastoris* (L.) Britton, *Silene antirrhina* L., *Polygonum erectum* L., *Rumex acetosella* L., *Rumex salicifolius* Weinm., and *Rumex verticillatus* L.

At the close of the season of 1897, I had about an equal number of good preparations of the last two species and had learned that *Rumex verticillatus* is a much more favorable plant for study than *Rumex salicifolius* because of the larger size of the structures to be investigated. Consequently, during the latter part of August, 1897, after previous study of the former plant had enabled me to select methods which seemed best adapted to my purpose, a large number of flowers and buds, selected to represent various stages of development of the gametophyte, were preserved for future study. During the summer of 1898 over three thousand macrosporangia were sectioned, and the drawings presented with this paper were reproduced from the preparations that gave the best results. *Rumex salicifolius* was also further studied in 1898, and the series of slides of this plant is nearly as complete as that for *Rumex verticillatus*. As the two plants gave very similar results, except for size of structures, I have not thought it necessary to multiply figures by giving a full series for both plants. The figures then are, in the main, drawn from preparations from the latter plant; those from the former being introduced only when the equivalent phases of development were not found in the other plant, or were poorly exhibited in the preparations.

The plants of the genus studied are not well adapted to the study of nuclear mechanism and phenomena because of the small size of the cells and contained nuclei, and I have consequently confined myself to other phases of the subject. Nor have I found anything in the study that would give additional evidence as to the nature of various structures within the embryo sac so that my work resolves itself into a description of the gametophyte and some comparative studies.

Under the subject stated I shall, for the sake of relationships, begin with the archesporium, which is the last term in the sporophytic generation and also include stages immediately following the establishment of the sporophyte.

So far as I know this is the first work done on the female gametophyte of *Rumex*, or of any plant within the Polygonaceæ, except *Polygonum divaricatum*, which has been investigated by Strasburger.

I am under obligations to Professor Conway MacMillan for helpful suggestions as to technique and interpretation of structure and for access to the literature of the subject.

Origin of the Macrospore.—At about the usual stage in the development of the macrosporangium, an axial hypodermal cell at the summit of the nucellus begins to enlarge and soon contains a larger nucleus and denser cytoplasm than the surrounding cells (Fig. 1). This cell constitutes the archesporium, and in all instances examined, only one cell showed this archesporial nature. The archesporium in plants may develop directly into the macrospore; it may itself become a sporogenous cell (mother cell) and divide into a number of potential macrospores; or more commonly it divides first into a tapetum and a sporogenous cell, each of which may divide, forming a cellular tissue. In *Rumex* the last order of development is followed. After increasing considerably in size (comp. Figs. 1 and 2), the archesporium divides by a periclinal wall into the inner sporogenous cell (the mother cell of the macrospore), and the outer hypodermal tapetum (Fig. 2). This apparently protective tapetum proceeds next to divide, sometimes by a periclinal wall (Fig. 4), but no doubt much more commonly by an anticlinal (Fig. 3). In no instance did I observe more than four tapetal cells derived from the primary tapetum and often only three, one of the two derived from the primary tapetum apparently failing to divide. Indeed, sometimes only one tapetal cell could be distinguished at a period of development which led to the suspicion that the tapetum may sometimes fail to divide. Fig. 5 shows four tapetal cells and the sporogenous cell below somewhat more elongated than usual with its nucleus unusually near its upper end. That this elongated cell is the mother cell of the macrospore instead of the macrospore itself is proved by the outline of the inner seed coat, which shows its early development as compared with its more advanced condition before the macrospore is produced (Fig. 10). Fig. 6 represents a single tapetum lying above a dividing mother cell, and this may be the original tapetum which has failed to divide, though a cell lying almost directly below it, and hence not shown in the figure, may have been a second tapetal. Fig. 3 shows a typical mother cell apparently about ready to divide, and showing two tapetals, neither of which would be likely to divide again.

After the formation of the protective cap of tapetal cells and the enlargement of the mother cell of the macrospore, the latter divides as usual, among the Archechlamydeæ at least, into a row of four potential macrospores. It is here that our subject proper really opens since this mother cell, in which the reduction of chromosomes takes place, stands between the sporophytic and gametophytic generations, connected morphologically with the former and physiologically with the latter. As the mother cell divides the nucleus lies longitudinally at or a little above the center of the cell (Fig. 6). As elsewhere in these studies, the number of chromosomes could not be made out, but, in all probability through failure to get a complete view of individual chromosomes, there really seemed to be twenty-four in this nucleus. The two cells resulting from this division were not seen, but from the position of the dividing nucleus in several instances observed, it may be assumed that the division is into two cells of approximately equal size as observed by Strasburger* in *Polygonum divaricatum.* This dividing nucleus of the mother cell of the macrospore was about as large as that of the macrospore itself (Fig. 9) and, being like the latter a nucleus of a large well-fed and consequently somewhat inactive cell, was apparently a long time in dividing. The reduction of chromosomes is supposed to be a process involving more time than is commonly occupied in mitotic division of nuclei; and this process doubtless also added further to the time occupied by this mother

* Strasburger, E. Die Angiospermen und die Gymnospermen, p. 5, 1879.

cell nucleus in dividing, so that it was seen dividing much more frequently than the equally large and apparently as well-fed nucleus of the macrospore.

As stated above the two cells resulting from the division of the macrospore mother cell were not seen in the resting condition, though the four potential macrospores resulting from their division were frequently found. The two cells were seen once with their nuclei dividing, but the nuclei were indistinct because of improper staining. The two-celled condition, which was not seen, is doubtless a very transient phase, the upper of the two cells almost immediately cutting off a small cell from its lower end, and the lower of the two likewise dividing at once into two cells, a large one below and a small one above (Fig. 7). This four-celled stage seems to be constant and of quite long duration as it was frequently seen as represented in Fig. 7 or as in Fig. 10. In the latter the lower more successful cell which is to become the fertile macrospore has begun to absorb the other three potential macrospores for its own nourishment. This may be seen by observing the decrease in amount of cytoplasm contained in each of the three cells as compared with the same three in Fig. 7 and the swelling of the softened periclinal cell walls between any two of them and between the lowest one and the absorbing cell below. The next observed developmental condition was that in which the three cells were all absorbed except possibly a refractive cytoplasmic cap at the summit of the absorbing cell, which more probably represents a nearly absorbed tapetal cell (Fig. 8). This brings us to the macrospore as shown in the figure.

Germination of the Macrospore.—When first formed the macrospore has very nearly the shape of the four cells replaced and shows the nucleus at the center surrounded by cytoplasm, while the upper and lower ends are each occupied by a large vacuole. Though I cannot account for this apparent poverty in cytoplasm at this time, the condition seems to be typical. As the macrospore increases in size by the absorption of tapetal cells and those cells of the macrosporangium which surround its upper lateral wall, cytoplasm increases in amount (Fig. 9). In the figure the nucleus is lying in its usual longitudinal direction about the middle of the macrospore while dividing. Before the nucleus divides, the macrospore increases considerably in size by the absorption and pressing upon surrounding tissues (comp.

Figs. 8 and 9). The cavity of the macrospore, which I shall now designate by the usual name of embryo sac, continues to increase in size as it approaches the condition shown in Fig. 11 by the continual absorption and pressure upon surrounding cells. The relative position of cytoplasm and vacuoles in Fig. 9 is hardly normal, the nucleus of the macrospore more commonly lying along the central longitudinal axis of the spore. In another preparation showing the dividing nucleus of the macrospore, the nucleus was in this more usual position, and no vacuole was seen. Fig. 11 shows the two nuclei derived from the nucleus of the macrospore and two tapetals and two other sporangial cells nearly absorbed. Of these two nuclei it is quite common to find the lower one larger, probably as a result of better nourishment, and, apparently consequently giving rise in division to a larger number of chromosomes.

The condition as to chromosomes could not be studied, but I noticed relative sizes carefully. As instances of difference in size of the two nuclei, the researches of Sargant,* Mottier† and Guignard‡ may be cited. I examined a number of the embryo sacs showing the two nuclei, and it would seem that the lower nucleus becomes very slightly larger than the upper (Figs. 11 and 12). The slight difference may not be constant, and indeed in the closely related *Polygonum divaricatum* Strasburger§ shows the upper nucleus larger than the lower. This stage of development was quite frequently observed, but the next, in which two nuclei appear in each end of the sac, was only seen twice (Figs. 13 and 14). The first of the two figures shows the probable position of the two nuclei during division as a persistent spindle was seen between the anterior pair. Then the anterior pair seems to result from the division of a nucleus lying transversely in the anterior end of the sac and the posterior pair from a posterior nucleus lying longitudinally in the sac. This position of the two nuclei while dividing is the common one in plants so far as I can ascertain. Fig. 14 represents a later stage, in which the

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*Sargant, Ethel. The Formation of the Sexual Nuclei in *Lilium martagon*. I. Oögenesis. Annals of Bot. **10**: 464. S. 1896.

†Mottier, David M. Ueber das Verhalten der Kerne bei der Entwicklung des Embryosack und die Vorgänge bei der Befruchtung. Jahrbücher für wissenschaftliche Botanik **31**: 132. 1897.

‡Guignard, L. Nouvelles Études sur le Fecundation. Ann. des Sci. naturelles Botanique VII. **14**: 187. 1891.

§Strasburger, E. l. c. Fig. 15.

nuclei have changed position somewhat. A difference in size has frequently been observed here also, in some other plants the lower pair being larger. I may cite Guignard* again and also Mottier.† However, the last named investigator only states that the nuclei forming the lower pair are much larger just before dividing, distinctly stating‡ that at an earlier period the four are all of equal size. I did not observe this phase of development often enough to be certain that the size is the same at all times in *Rumex;* but it seems from the instances observed that, though coming from the nuclei differing somewhat in size, the four are so nearly of the same size at all times that any difference would be difficult to detect. During the change to the four-nucleate condition the sac increases somewhat in size, as may be seen by comparing Figs. 13 and 14 with Fig. 12.

The development from the four-nucleate to the eight-nucleate condition must be even more rapid than that from the two-nucleate to the four-nucleate phase, for I was neither able to find the two tetrads in position, nor the division of the four nuclei leading to its establishment. The nearest approach to it was observed in *Rumex salicifolius* (Fig. 15), when the polar nuclei were approaching. The condition represented in Fig. 15 is an especially interesting step in the life-history of the gametophyte of *Rumex* because of departure from the usual conditions and especially from the nearly related *Polygonum.* On examining the figures of Guignard, Vesque, Strasburger, Ward and others, I find that in fully five-sixths of their drawings they show cell walls about the three anterior cells before the polars have fused. Strasburger figures for *Polygonum divaricatum* § three nuclei enclosed in cellular membranes and one free nucleus in each tetrad even before the two polars begin to approach each other. My own observations on *Polygonum erectum* L. (Fig. 16), *Bursa bursa-pastoris* (L.) Britton and *Silene antirrhina* L. gave the same results so far as the anterior end of the sac is concerned, though the evanescent antipodals of *Bursa* were not satisfactorily studied in this respect. Methods which brought out these walls in the three plants named above should show them, if present in *Rumex*, yet in this genus I find all the an-

*Guignard, L., l. c. 188.
†Mottier, David M., l. c. 137.
‡Mottier, David M., l. c. 136.
§ Strasburger, E. l. c. Fig. 17.

terior three cells free while the polars are approaching each other in *Rumex salicifolius* (Fig. 15). When the polars have met, or are fusing in this plant, the cellulose walls seem to begin to form, and a suggestion of such a structure may occasionally be seen (Figs. 17 and 20) about the nuclei of the synergidæ. In *Rumex verticillatus*, even shortly after the definitive nucleus is formed (Fig. 18), I could only distinguish a suggestion of a beginning of formation of a membrane about the lower end of the egg while the sister nuclei which form the synergidæ were yet free. In *Rumex salicifolius* the synergidæ form earlier than in *Rumex verticillatus* and are more regular in form in the former plant (compare Fig. 24 with Figs. 19 and 23). So far as investigation has proceeded then, cell walls appear about the three anterior nuclei (excluding the anterior polar) before the meeting of the polar gametes in *Polygonum;* while in *Rumex* the walls appear after the meeting of the gametes, or even after their fusion to form the zygote constituting the definitive nucleus. The matter is one of some taxonomic interest, which can only be solved by a laborious study of all the species of the two genera with reference to this particular problem in developmental history.

Regarding conditions presented in Figs. 15, 17 and 20 some further statements are necessary. In these stages I was able to note no difference in size of the three anterior nuclei, while at later periods the nucleus of the egg had increased in size so that it was larger than those of the synergidæ (Figs. 18 and 19). So far as I could ascertain, the nuclei of the three antipodals were smaller than the three just discussed at all periods. Fig. 17 represents the three antipodals as best seen in *Rumex salicifolius*, and here their smaller size can be seen distinctly. The antipodals are difficult of observation at all times because of their lying in the small cæcum-like prolongation of the embryo sac so that, except in very thin sections, other cellular structures of the surrounding macrosporangium almost always partially or completely obscure them. In the sac of the same plant showing a slightly earlier stage of development (Fig. 15), only the deeply-stained nucleoli could be seen through the overlying tissues of the macrosporangium, neither the nuclear membrane nor the cellular wall about each of the three nuclei appearing. In this plant the three-celled antipodal area was found persisting in the latest phases studied after the establishment of the embryonic sporophyte (Fig. 33) and seems to be quite constant, though in the sac represented in Fig. 24 I suspect that there were really no walls about the antipodal nuclei. However, here again overlying tissues may have obscured them. *Rumex verticillatus* gave less satisfaction in the study of the antipodal region. In only one instance were three antipodals seen constituting a three-celled mass of tissue (Fig. 21). This figure represents the posterior end of a mature sac. In other instances various conditions of cell-wall formation were shown in this region before the establishment of the sporophyte (Figs. 23, 27 and 28). Sometimes more than three nuclei could be distinguished within this antipodal area (Figs. 23 and 28). After fertilization these cells seem to disintegrate more or less in this plant, and no such typical structure was found persisting as is figured for *Rumex salicifolius* (Fig. 33). The degenerating condition of the antipodal region just after fecundation is shown in Fig. 27, which is the lower end of the sac presented in Fig. 26. Here I was only able to make out a highly refractive area with neither walls nor nuclei. As to the time when the cellular membranes appear around the antipodal nuclei, I am not able to state certainly because of the difficulty encountered in investigation, but it seems, from the facts presented and other observed phenomena, that in *Rumex salicifolius* they form earlier than those about the three nuclei in the anterior end of the sac. In *Rumex verticillatus* walls were not detected till the time of maturity of the embryo sac when the typical three celled condition (Fig. 21) presented itself, or that of three or more nuclei within a common wall (Fig. 23). The antipodal area in *Rumex salicifolius* seems to agree substantially with the third of the four types proposed by Coulter* of "three comparatively permanent cells not notable for size or activity and usually associated with a sac decidedly narrowed at the antipodal end." The antipodals of *Rumex verticillatus* are not so permanent, but doubtless should be classed here also as should those of *Polygonum erectum*.

The size of the two polars in plants may differ as well as their place of fusion. Schaffner finds the upper one larger in *Alisma plantago*† and *Sagittaria variabilis*.‡ Also he finds in

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*Coulter, John M. Contribution to the Life-History of *Ranunculus*. Bot. Gaz. **25**: 80–81. F. 1898.

† Schaffner, John H. The Embryo Sac of *Alisma plantago*. Bot. Gaz. **21**: 126. Mr. 1896.

‡ Schaffner, John H. Contribution to the Life History of *Sagittaria variabilis*. Bot. Gaz. **23**: 255. Ap. 1897.

the last plants that the two polars fuse in the lower part of the sac, the larger gamete strangely enough traveling further than the smaller and thus showing greater activity. Mottier * finds them of about the same size in *Senecio aureus* and that they fuse in the anterior end of the sac just below the egg, the lower of the two equal-sized polars thus showing greater activity. In *Rumex*, and all of the Polygonaceæ so far as studied, the two polar nuclei are of about the same size (Figs. 15, 17 and 20) and fused at or near the center of the sac.

During the passage from the four-nucleate to the eight-nucleate condition, the sac increases considerably in size (comp. Figs. 13 and 15), and the increase in size is even more noticeable as the sac matures (comp. Figs. 15 and 24).

The Mature Embryo Sac.—The mature sac contains typically the usual seven nuclei, though in *Rumex verticillatus*, as stated elsewhere, the number in the antipodal region may vary, producing a corresponding variation in the total number contained in the sac. In *Rumex verticillatus* the synergidæ are somewhat irregular in form (Figs. 19 and 23), while in *Rumex salicifolius* they are more regular in outline (Fig. 24). The egg usually lies in contact with the lower part of one synergid in both plants (Figs. 19, 23 and 24), and its nucleus is much larger than those of the synergidæ. All three nuclei are enclosed in definite walls at this time. The definitive nucleus is much the largest nucleus in the sac (Figs. 18, 23, 24, 25 and 28). In *Rumex verticillatus* it usually approaches the egg after formation and lies close to it till the time for fecundation approaches (Fig. 23) when it commonly recedes somewhat (Figs. 25 and 26). In *Rumex salicifolius* it usually lies at some distance from the egg in the mature sac (Fig. 24) though it was once seen nearer in an earlier stage (Fig. 22). In *Rumex salicifolius* it may be assumed that the antipodals are in the typical three-celled condition at maturity as they were observed in this condition both before and after as already stated (Figs. 17 and 33). As before noted the condition of the antipodals in Fig. 24 is doubtful. The condition of the antipodals in *Rumex verticillatus* at this time has also been explained above.

In shape the mature sac in both plants differs quite widely from that of *Polygonum divaricatum* as shown in Strasburger's

* Mottier, David M. On the Embryo Sac of *Senecio aureus.* Bot. Gaz. 18: Fig. 1 and p. 248. Jl. 1893.

figure,* the largest part being near the anterior end and the posterior narrowed end being quite long (Figs. 17, 23, 24, etc.) while his figures show the narrowed posterior cæcum dilating quite abruptly, making the posterior half of the mature sac quite as large as the anterior half. *Polygonum erectum* the mature sac is much more like *Rumex* than *Polygonum divaricatum* as figured by Strasburger.

Fecundation, and the origin of the Sporophyte. During the period of fecundation and the establishment of the sporophyte, the embryo sac continues to increase in size rapidly, as may be seen by comparing Figs. 24 and 33 and also 23 and 30, making allowance for the greater reduction of Figs. 30 and 33.

The first evidence of a pollen tube approaching or already present in the sac is the disappearance of one of the synergidæ (Fig. 25). When actually present the tube is an easy object to detect because it stains more deeply than surrounding tissues, hence in those instances in which one synergid was breaking down while no tube could be distinguished, I have concluded that the tube was just approaching the sac. In Fig. 25 the tube has not yet discharged, as it shows two nuclei and the end is intact, and it lies as usual beside the persistent synergid. The definitive nucleus here occupies a position at some distance from the egg as it frequently does at this time. Here this nucleus is in a resting condition, and I find it so constantly up to this time. After the pollen tube has discharged the remaining synergid disappears, and the definitive nucleus soon divides (Fig. 26). Though in some plants the definitive nucleus seems to divide sometimes before the entrance of the pollen tube into the sac, its presence in the style probably furnishing the necessary stimulus, it does not divide till after the entrance of the tube in *Rumex verticillatus* and probably usually not till after the fecundation of the egg. In the discharge of the sperm nucleus the tip of the tube is ruptured as shown in Figs. 26, 29, 30 and 35. After the pollen tube has discharged a deeply stained spot may always be seen within the tube as shown in the same figures. This is the shrunken second and undischarged sperm nucleus. The fusion of the sexual nuclei was only seen once, and in that instance the egg was badly distorted. The tube in this case was closely applied to the egg though the figures given herewith seem to indicate that this

* Strasburger, E. l. c. Fig. 21.

is not the usual relation during fusion of these nuclei. The conditions existing in Fig. 28 are somewhat of an enigma. The sac is surely larger than it could be previous to fecundation, but the two smaller nuclei in the anterior end look like those of the synergidæ. Also the definitive nucleus lies near the egg as I uniformly find it in *Rumex verticillatus* before fecundation. I thought for a time that I had here a pollen tube showing one sperm nucleus within and the other discharged and entering the egg. However, taking into account the appearance of the two smaller nuclei and the restful condition of the egg, I have concluded that the sac is one whose egg failed to be fertilized and in which one synergid has disintegrated leaving its nucleus while the other is rapidly dwindling. If this is true, the sac has gone on increasing in size the same as if the egg had been fecundated. The next stage observed after that already explained (Fig. 26) is that represented in Fig. 30, in which the tube had discharged, the first two endosperm nuclei had divided and the spindles were persisting, and the egg was evidently preparing to divide. A little later phase was also found (Fig. 29), in which the tube was persisting and showed the broken end beautifully, the egg was dividing and three of a probable four endosperm nuclei were visible. The tube frequently persists in both plants till the sporophyte is well established (Fig. 35), and in one instance an undischarged tube was seen in the sac of *Rumex verticillatus* after the embryo was well established and four endosperm nuclei were dividing (Fig. 34). This tube, containing two sperm nuclei, is a second one which entered the sac after fecundation had been accomplished.

An exhaustive study of the embryo will not be attempted; but I shall state a few observed facts concerning its origin and early development, making no use of the terms suspensor and proembryo, but designating the structure from the beginning as the embryo. The first division then of the embryo occurs soon after the egg has elongated and secreted a cellulose wall about its base to attach it to the anterior end of the sac and is transverse (Fig. 29). The second and third divisions were also transverse in several instances observed (Fig. 35), and the fourth was a longitudinal division of the distal cell of the embryo (Fig. 31). In an instance observed the third division was transverse and closely followed by a longitudinal dividing the second cell from the distal end (Fig. 32). During its early development the embryo is not always attached centrally at the anterior end of the sac, nor does it often lie in an exactly longitudinal direction in the sac.

It has already been stated that the definite nucleus in *Rumex* does not divide till after fecundation of the egg, an observation based upon examination of two or three hundred sacs. It is worthy of note that the endosperm nuclei observed while dividing in any given sac were all in the same mitotic phase (Figs. 30 and 34). The last figure shows only one of four nuclei observed dividing. The endosperm nuclei were not so numerous, at the stages studied, in *Rumex verticillatus* as in *Rumex salicifolius* (Fig. 33); nor were they yet enclosed in cell walls in either plant.

Relation of the Gametophyte to the Macrosporangium.—I have studied carefully the position of the base of the sporogenous tissues and derived embryo sac with reference to lines connecting the points of origin of the seed coats in order to ascertain how much of the enlargement of these structures is associated with a downward growth and consequent crowding of the tissues of the macrosporangium and how much is accomplished by upward growth, keeping pace with the growth of the nucellus. The position of the base of sporogenous tissue, and later of the sac, with reference to these lines is not always quite the same at any particular stage of development; but by comparative study, safe conclusions have been secured. Between the base of the archesporium and the lines connecting the supposed points of origin of the future seed coat are five or six cells. After the tapetum is cut off (Fig. 2), there are only three or four cells between the base of the mother cell of the macrospore and the lines. By the time of division of the tapetum (Fig. 3) the base of the mother cell is within two or three cells of these lines. During this time the nucellus has increased in length very little, its increase in size being principally in width. Consequently, this fact, together with the relative position of the base of sporogenous tissue and the lines at various stages of development, indicates that the sporogenous tissue has grown downward in the nucellus. As no evidence of absorption of cells was seen at this time, I conclude that this downward growth is accomplished by crowding downward and outward the subjacent layers of cells of the macrosporangium. However, the effects of the crowding were so distributed among several layers of cells that they were scarcely visible in any particular cell. After the mother cell has reached its full length, there is no further downward growth, the further increase in length of the sporogenous tissues and subsequently of the sac being accompanied by a proportionate elongation of the nucellus. By the time of the establishment of the macrospore, a thickening of the walls of cells in the chalazal region for the support of structures above has begun in a layer of cells extending transversely between the points of origin of the inner seed coat. As the superimposed structures become heavier, the thickening extends to several layers of cells below the ones first thickened and gives rise to quite a mass of thick-walled tissue extending entirely across the chalazal region.

As the macrospore matures and prepares to divide (Fig. 9), absorption of tapetals above and pressure on surrounding cells of the upper nucellus becomes evident and is apparent in all subsequent stages of development of the gametophyte. However, the swelling of the cell walls of the upper nucellar tissue just beneath the epidermis as observed by Strasburger* in *Polygonum divaricatum* as a result of absorption I have not seen either in *Rumex* or *Polygonum*.

By the time development has proceeded to the condition represented in Fig. 11, the subepidermal cells of the upper end of the nucellus have all been absorbed, and from this time on till the establishment of the conditions shown in Fig. 28, or possibly not later than those shown in Figs. 25 or 26, the increase in size is due, at least principally, to the absorption of cells of the nucellus surrounding the middle portion of the sac, which still continues to increase in size. During this time the sac is increasing in length, and since there has been no further sinking of its posterior end into subjacent tissues, as is shown by the fact that its lower end is still removed from the lines connecting the points of origin of the inner seed coat by two or three cells, as was the lower end of the mother cell, this increase in length is accompanied by an equal upward growth of the nucellus. Dividing nuclei were seen in the basal region of the nucellus, both in the epidermis and in the sub-epidermal cells, up to the latest stages studied, indicating that this basal portion of the nucellus is its chief region of growth at these stages. After the growing gametophyte has absorbed all the sub-epidermal tissues of the

*Strasburger, E. l. c. Figs. 10 et seq.

upper nucellus, the sac does not cease to expand laterally, but presses the remaining epidermis of this portion of the nucellus outward as it still further increases in size. These epidermal cells contain cytoplasm and may divide even after the cells of the inner nucellus, or their cytoplasmic contents, at least, have been absorbed; but the increase in epidermal surface accompanying the continued increase in size of the sac is doubtless due principally to increase in length of these upper epidermal cells and the division of those near the base of the nucellus.

Fig. 28 shows certain of these conditions of the nucellus brought about by absorption of its tissues by the growing gametophyte and by its own growth. All of the epidermal cells except those at the summit show elongation in the direction of upward growth of the nucellus. All of the epidermal cells except those at the summit are also well filled with cytoplasm, indicating activity. The lowest sub-epidermal cells of the nucellus shown in the figure are also well filled as were the cells of five or six layers lying between the lowest shown in the figure and the area of thickened cells in the chalazal region. In passing upward from the base to the summit of the nucellus, we find greater and greater absorption of the cytoplasmic cell-contents and finally a partial breaking down of the cell walls and a beginning of the consequent collapsing of the cells. In the lower portion of the nucellus the absorption by the gametophyte has only affected the layers of cells near the sac, while in the upper portions all of the sub-epidermal cells are affected. The upper and older cells of the nucellus, where not too much disintegrated, also show an increase in size over those of younger nucelli, which accounts in part for the elongation of this organ as it keeps pace with the growth of the sac.

Methods.—After trying one per cent. solution of osmic acid, one-half per cent. and one per cent. chromic acid, a saturated solution of corrosive sublimate in seventy per cent. alcohol and the last two plus a small addition of acetic acid to prevent shrinkage, the corrosive sublimate with acetic acid was found to give best results. The sections thus fixed also took best the stains used.

After this method of fixing, the tissues were washed in seventy per cent. alcohol containing iodine, gradually transferred to absolute alcohol, imbedded in paraffine through xylol, stained and mounted in balsam in the usual way. Alcohol safranin followed by methyl blue was found to be the best stain for stages before the establishment of the macrospore, and safranin or Delafield's hæmatoxylin gave best results from this period up to the fecundation of the egg, after which the hæmatoxylin proved best.

The nucellus of *Polygonum erectum* is transparent enough to show the nuclei of various stages of development of the sac, except the antipodals, as well as the cytoplasm and vacuoles with oil immersion lens, without sectioning or any treatment whatever. The results, however, were not reliable enough for my purpose, nor are they certain enough for use in instruction.

The figures are all drawn to the same scale by using one-inch Leitz eye piece, one and one-half-inch Leitz objective and camera lucida.

Explanation of Plates.

NOTE.—All figures are of *Rumex verticillatus* unless otherwise indicated. The figures of the first two plates are reduced to one-half the original size of drawings, those of the last two to one-third.

Plate IX.

1. Upper portion of nucellus showing the archesporium.

2. Later stage showing the primary tapetum cut off above and the mother cell of the embryo sac below.

3. The tapetum has divided into two tapetal cells and the mother cell has increased considerably in size.

4. Stage between 2 and 3 showing the tapetum dividing.

5. Four tapetal cells and the elongated mother cell.

6. The mother cell dividing and one tapetal cell above.

7. The four potential macrospores derived from the mother cell.

8. The macrospore and a highly refractive cytoplasmic cap, representing an almost completely absorbed cell, either a tapetal cell or the upper one of the potential macrospores.

9. The nucleus of the macrospore dividing.

10. A somewhat older stage than 7 and showing the upper three potential macrospores partly absorbed by the lowest one, which is to become the macrospore.

11. Embryo sac containing two nuclei resulting from the division of the nucleus of the macrospore, the lower one being somewhat larger. The highly refractive remains of four nearly absorbed cells of the nucellus are also shown.

Plate X.

12. Embryo sac of *Rumex salicifolius* showing the two nuclei as above and the lower one also slightly larger.

13. Embryo sac of *Rumex salicifolius* showing the four nuclei derived from division of two corresponding to those figured in 11 and 12, and also showing the persistent spindle in the anterior end of the sac.

14. Embryo sac of *Rumex salicifolius* showing the corresponding four nuclei in a somewhat older sac.

15. Embryo sac of *Rumex salicifolius* showing eight nuclei derived from four corresponding to those figured in 13 and 14. The polar nuclei are approaching each other. The three anterior nuclei are of about equal size and not enclosed in walls. Only the nucleoli of the antipodals could be seen.

16. Embryo sac of *Polygonum erectum* showing the earlier formation of cell walls about the anterior nuclei, one of which was lying below the other two. The polar nuclei are approaching each other, and the cellular structure in the antipodal area is distinct, one cell here also lying below the other two.

17. Embryo sac of *Rumex salicifolius* showing the egg yet free, cell walls forming about the synergidæ, the polar nuclei fusing and three distinct nucleated antipodal cells.

18. Embryo sac showing the sister nuclei which form the synergidæ yet free and the wall forming about the egg after the definitive nucleus is formed.

19. Anterior end of a mature embryo sac showing the synergidæ and the egg.

20. Embryo sac of *Rumex salicifolius* showing all of the nuclei of the mature sac, except the antipodals and at about the same stage as the corresponding nuclei in 17.

21. Posterior end of a mature embryo sac showing three antipodal cells.

22. Anterior end of the embryo sac of *Rumex salicifolius* showing walls forming about the egg after the definitive nucleus is formed.

23. Mature embryo sac showing more than three nuclei in the antipodal end.

24. Mature embryo sac of *Rumex salicifolius*, with the antipodal region perhaps not distinctly seen.

Plate XI.

25. Anterior end of embryo sac showing one synergid degenerated, the pollen tube entering and showing two nuclei very indistinctly. The egg and definitive nucleus are also shown.

26. Anterior end of embryo sac showing a pollen tube discharged and containing an undischarged sperm-nucleus. The two synergidæ

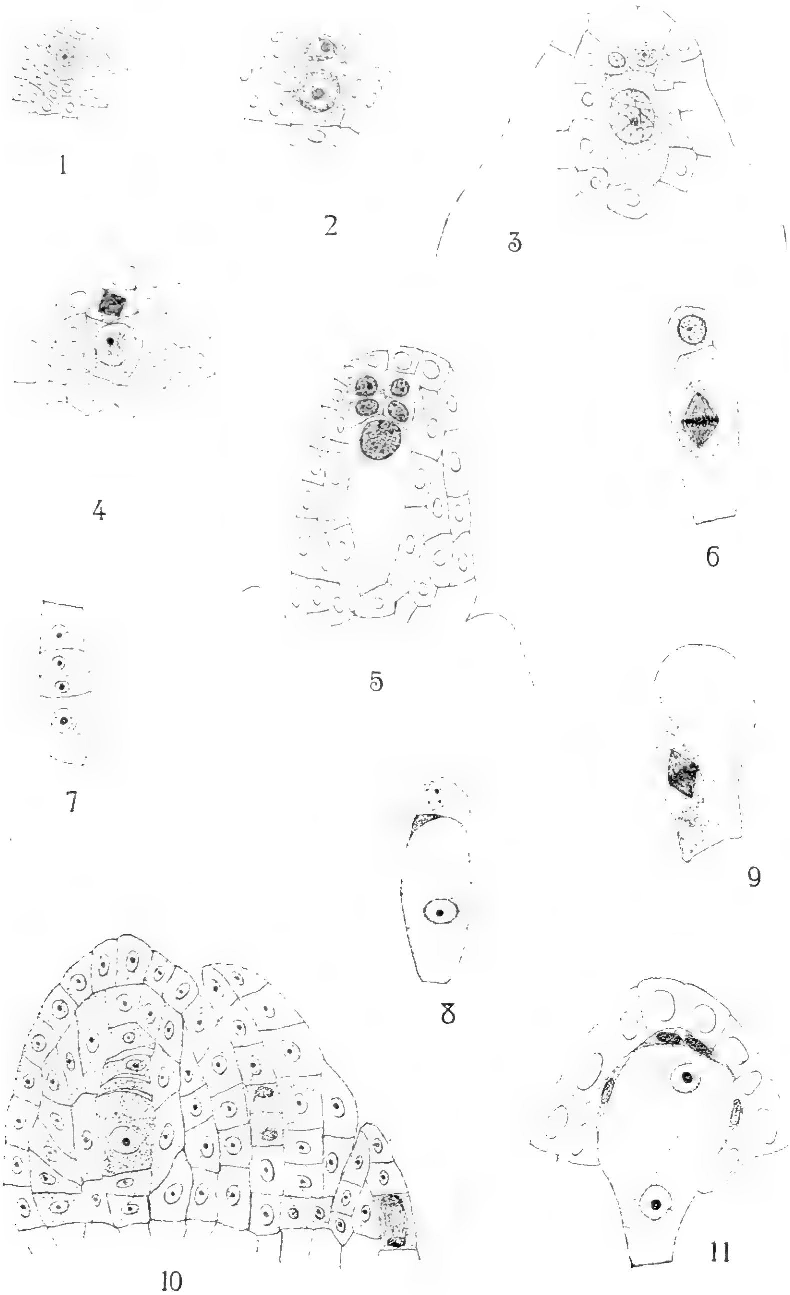

PLATE IX.

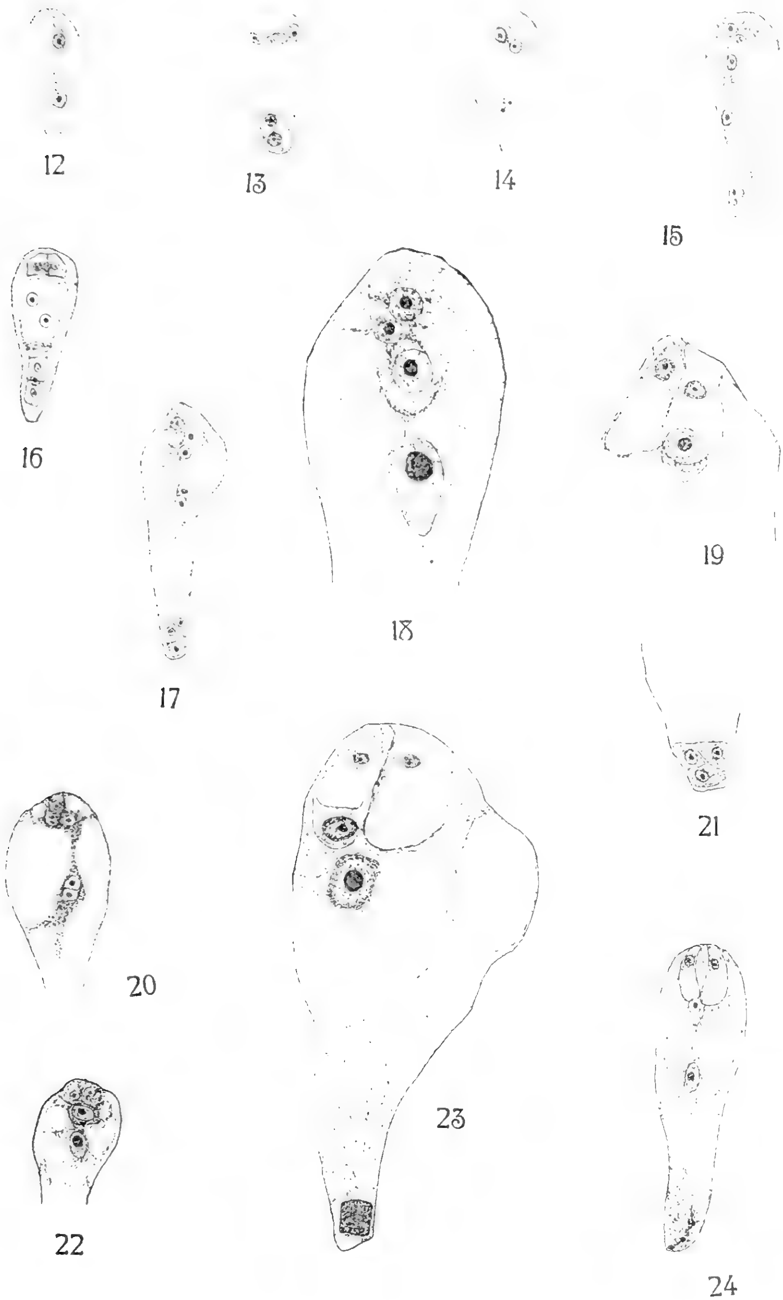

PLATE X.

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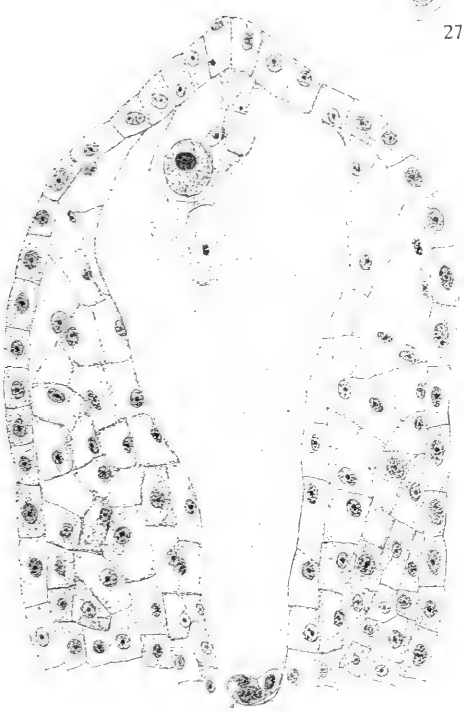

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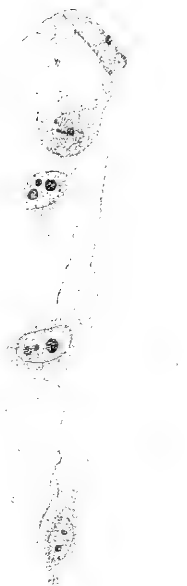

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PLATE XI.

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PLATE XII.

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have degenerated, the fecundated egg is extending its cell wall upward to attach it to the anterior end of the sac and the definitive nucleus is dividing.

27. Posterior end of the sac whose anterior end is shown in 26. The antipodals are degenerating.

28. Embryo sac and surrounding tissue of the nucleus showing mutual relations of the two structures.

29. Anterior portion of embryo sac showing three of a probable four endosperm nuclei, pollen tube ruptured at the end and the egg dividing to form the two-celled embryo.

Plate XII.

30. Anterior end of an embryo sac somewhat younger than that figured in 29 and showing the discharged pollen tube, the egg apparently preparing to divide, and four endosperm nuclei with a spindle persisting between each pair.

31. Anterior end of embryo sac showing a five-celled embryo and three endosperm nuclei.

32. Young embryo in anterior end of embryo sac showing four newly formed nuclei and two persistent spindles.

33. Embryo sac of *Rumex salicifolius* showing a somewhat more advanced embryo, a larger number of endosperm nuclei and the antipodals still persisting.

34. Anterior end of embryo sac showing five-celled embryo, one of four observed dividing endosperm nuclei, and an undischarged pollen tube which entered the sac after the egg was fecundated.

35. Anterior end of embryo sac of *Rumex salicifolius* showing three-celled embryo, whose middle cell is dividing, and the persistent discharged pollen tube in the micropyle and extending into the sac.

XI. OBSERVATIONS ON GIGARTINA.

MARY E. OLSON.

The genus *Gigartina* is of wide distribution, especially in temperate latitudes. It is found both in the Atlantic and Pacific oceans as far north as the coast of Greenland and as far south as Cape Horn.

The material used in preparing this paper was collected in Puget Sound, at Channel Rocks, near Seattle, Washington, on August 3, 1897. It does not correspond exactly with any of the specific descriptions recorded. Indeed it has been with some reluctance that this plant has been included in *Gigartina*.

The material used for study in the preparation of this paper had been preserved in 75 per cent. alcohol, with the exception of some dried material which was studied in determining the color, size, shape and other external characters.

In the dried material the fronds appear thin and membranaceous and very brittle. The alcoholic material is leathery in texture and quite tough. The older fronds show a considerable increase in thickness over the younger ones, and are strongly *Calliblepharis*-like in appearance.

HABIT AND EXTERNAL APPEARANCE.

The fronds are reddish purple in color and occur at a depth of eight fathoms. Several or more fronds are generally found growing crowded together from united holdfasts. Such a group is seen in Fig. 1, Pl. 13.

The general outline of a frond whether branched or unbranched is typically cuneate. Fig. 3, Pl. 13 shows a good specimen of the unbranched type. When branched the general wedge-shaped outline is retained by a more or less regular, dichotomous form of branching, in which the branches spread and remain of considerable width. (Fig. 1, Pl. 13.)

Holdfast.—The holdfast is disc-like, and varies in size according to the number of plants springing from it. In an isolated individual (Fig. 3, Pl. 13) it is seen to be but little larger than the circumference of the base of the stipe. On the under side, by which it is attached to the substratum, it is seen to have a smooth surface, and two areas are clearly distinguishable in the alcoholic material used in this study; a central, nearly circular almost translucent area, and an outer apparently denser portion (Fig. 3, Pl. 13). When viewed from the upper side the significance of these areas is understood. If a large holdfast be examined, from which part of the fronds have been removed, the upper surface will be seen to be uneven and dotted with circular pits bordered by very distinct rims (Fig. 6, Pl. 13). On running the point of a needle through one of the translucent areas of the under side it is found to correspond with the pit of the upper side. A still more interesting demonstration is to pull away one of the fronds still attached to the holdfast. If this be done carefully it will be seen that a characteristic pit remains to mark the point of attachment of the stipe. An old holdfast is found to be covered with these scars, which are very perfect markings of the outline of the stipe at the point of attachment.

Stipe.—The stipe is a well-marked organ whose presence is more or less evident in all the plants, especially as they attain their mature size. Some of the members of the group in Fig. 1, Pl. 13, show that in the first stages the width of the frond varies but little from the base to the tip, so that a distinct stipe is scarcely distinguishable. Very soon, however, the upper portion of the frond begins to expand and a typical stipe becomes evident. Its outline just at the point of attachment to the holdfast is circular, but above this it becomes slightly compressed in one diameter so that its cross section appears oval or elliptical. The transition trom stipe to lamina is so gradual that no distinct demarcation can be detected between them. The shorter diameter becomes still shorter, and the longer one increases to the width of the frond till all appearance of the stipe has vanished and even the greater thickness at the center of the lamina merges so gradually into the thinner margins that it cannot be be said to be present as a midrib.

Lamina.—The lamina is seen to attain its greatest width at some little distance from the tip. If it is branched the division is dichotomous, though the lobes are often unequal in size, and occurs near the tip of the frond, so that there is no branching of the stipe. The margins present a more or less wavy, undulating outline. In fertile fronds the margins all along the upper part of the frond are prolonged into little leaf-like outgrowths bearing the cystocarps (Fig. 2, Pl. 13). These proliferations also occur on the surface of the frond and sometimes are scarely more than the stalk of the single cystocarps they bear. In many fertile fronds the surface is almost entirely covered with these outgrowths. As a rule they occur much more densely on one side than the other. Frequently they are found as simple small leaflets bearing no cystocarps. Their presence gives a look to the lamina quite suggestive of fruiting *Calliblepharis*.

Internal Anatomy.

Holdfast.—A section of the holdfast shows a very distinctive structure unlike anything seen elsewhere in the plant. The appearance of a section is seen in Fig. 9, Pl. 13, showing the outline of the pit or scar and the depression from which the stipe was removed. The cellular structure varies but little from the general type except in the transition zone from the holdfast to the stipe. Along the upper surface the cells are covered by a gelatinous envelope or cuticle of considerable thickness often 15 mic. deep (Fig. 10 a, Pl. 13). This, of course, in one of the scars extends only to the border of the pit as indicated in Fig. 9, Pl. 13. Some sections also show a similar layer on the lower side at joints (Fig. 9 b, Pl. 9), while the remainder of the lower surface shows a rough irregular margin of cells (Fig. 9 c, Pl. 13). The possible explanation suggests itself that the cuticle, when occurring on the lower side, appears at joints which, through some unevenness of the substratum, are not closely appressed to it and hence are left exposed as it were.

The tissue of the holdfast is characterized by cells having a quadrilateral outline as seen in zone "b" in the right-hand part of Fig. 10, Pl. 13. This general type becomes greatly modified in various regions. In the transition zone "c" (Fig. 10, Pl. 13), from the holdfast to the stipe, the angular outline of the cells disappears and they become more rounded and smaller in size. In all regions cells of irregular outline are frequently met with scattered among the cells of typical quadrilateral outline.

In general the cells are arranged in approximately regular rows extending vertically through the holdfast. This is more apparent outside the region of the pit than within. In passing from the holdfast proper to the stipe the character of the cells is seen to change, the outline becomes rounded, the cells smaller and the arrangement very irregular (Fig. 10 c, Pl. 13). On the upper side of this zone the cells become elongated and soon merge into the structure of the stipe (Fig. 10 d, Pl. 13). At the side, in the region where the surface of the holdfast passes to the surface of the stipe, an interesting curvature of the rows of cells of the holdfast is noticed (Fig. 10 e, Pl. 13). The upper cells of the holdfast gradually become smaller and merge into the outer cells of the stipe, so that at the periphery there is not so marked a change in the character of the cells as in the center. The central elongated cells of this stipe extend farther into the holdfast in the center than at the periphery of the stipe region. This is to be expected from the outline of the pits from which the stipe has been removed, and an examination of these pits under high power reveals the fact that none of the elongated stipe cells are present in the scar, showing that the separation zone when a stipe is pulled from a holdfast is at the region shown in Fig. 10, Pl. 13 at c, and curves upward at the sides, thereby forming the pit-like scar.

In many sections of stipe and holdfast the elongated cells are seen to extend much farther down than in the section of Fig. 10, Pl. 13, so that only one or two layers of holdfast cells lie between them and the lower surface.

In a few sections an interesting development of outgrowths on the lower surface was noticed. These occur below the stipe region and show the same cellular structure as the holdfast proper. They are apparently rhizoid-like growths (Fig. 10, Pl. 13).

The sections used were placed in an alcoholic solution of fuchsin for a few moments, then washed with alcohol and mounted in glycerine jelly. The stain failed to bring out any cell contents and to all appearances the cells are empty.

Stipe and Lamina.—The structure of the stipe and lamina is very similar, the chief difference being that in the former the cells are of somewhat smaller diameter.

The upright portion of the plant may be divided, anatomically, into two fairly distinct portions: the pith, consisting of the larger, apparently empty cells and the cortex, of smaller cells containing the chromatophores. Because of this difference in the cells the sections for the structure of the stipe and lamina show the outlines of the cell wall in the pith, but in nearly all the sections examined the cell walls of the cortex could not be distinguished, and it is the outline of the cell contents that is represented in such sections.

The inner portion or pith consists of elongated, cylindrical cells, united into loosely interwoven filaments, extending principally in the direction of the long axis of the frond. The union between cells is so irregular that often the filamentous arrangement is scarcely recognizable. Surrounding this pith region, which is of compressed cylindrical contour in the stipe, is the cortex, which consists of much smaller cells, arranged in radiating rows, more or less regular, perpendicular to the surface of the frond.

Pith.—The transverse sections of both stipe and lamina show the cross-sectional outline of the pith cells to be more or less circular with considerable space between the cells (Figs. 12 and 13, Pl. 13). In the lamina portions of a filament are often found running through the section. The outlines of the pith cells in both lamina and stipe show an area of larger cells just within the cortex, passing inward to a central portion of smaller diameter (Fig. 11, Pl. 13). Within the pith itself there is considerable variation in the size of the cells, showing that smaller filaments anastomose with the larger ones.

The average size of the cells is from 100 to 170 mic. long by 17 to 33 mic. wide. The most interesting feature of the pith is the presence of protoplasmic pits connecting the cells. These occur not only in the end walls, but also in the lateral walls, as seen in Fig. 11, Pl. 12. By these connections, as well as by lateral pressure in some cases, the cylindrical outline of the cells becomes variously modified.

Communication of adjacent cells of the pith region is thus completely established. The significance of this will be more clearly seen as the physiological importance of this area is discussed. These pits were first discovered by staining with hæmatoxylin. A more careful trial of different stains showed that these pits always take the stain more deeply than any other part, either cell contents or cell wall. Both methyl violet and fuchsin produced good results. An alcoholic solution of the stain was used.

A study of these pits showed them to be of the form of small plates or rings, apparently one in each of the two adjacent cells (Figs. 11 and 13, Pl. 9). When seen edgewise they appear as two small plates narrower than the width of the cell wall, so that the inner line of the cell wall appears to curve out to meet them. Often the entire outline of one ring may be seen and only part of the other, which apparently lies beneath it. Again the section will lie so as to show both rings.

Some sections, especially with the methyl violet, showed a faint outline of cell contents just within the wall and in all cases extending close up to the rings or pits. Careful observations of this sort led to the opinion that these connecting pits must be of the nature of the protoplasmic cell contents rather than the cell wall. Schmitz confirms this opinion. Unfortunately the writer did not have access to Schmitz's original article, but in George Murray's *Introduction to the study of Seaweeds*, 1895, in the chapter on Rhodophyceæ (which he states is based upon Schmitz's papers) the following is found (p. 201): "The plates stand in direct connection with the protoplasm lining the cell wall and are, in fact, so coherent with it that they may be regarded as transformed or rather differentiated protoplasm locally covering the pit. However it is probable that a thin layer of protoplasm covers them in turn."

All observations have gone to show that there is an intimate protoplasmic connection between the contents of neighboring cells. Zimmermann's Botanical Microtechnique was consulted as to re-agents for testing these rings.

The use of sulphuric acid and a mixture of iodine and potassium iodide is recommended for cellulose walls giving a blue color. This was used, but neither the cell walls nor the pits showed any trace of blue staining. Cuprammonia was also tried, but with no success. Some interesting results were obtained, however, with the use of sulphuric acid. The sections were first stained and then treated with the acid. Although the acid at once destroyed the original color it was found better results were obtained than without first staining. A trial was then made as to the strength of acid which would give most satisfactory results, and it was found that treating sections prepared as before described, with a 50 to 60 per cent. solution of the acid produces at first no apparent effect beyond a slight swelling of the cell wall. The sections were left mounted in the acid, and after twenty-four hours re-examined. It was then found that the cell walls were all dissolved and only the rings remained (Fig. 17, Pl. 14). This leads to the conclusion that the rings are not of the same composition as the cell wall.

The pith of the cystocarpic proliferations of the frond shows a marked difference from that of the vegetative portion (Fig. 18, Pl. 14). The cells have become very irregular in outline and are so anastomosed and interwoven as to form a network which becomes more and more dense in passing from the stalk to the pericarp proper. Here, as well as in the cortex, the cell contents have a dense granular appearance, and the cell walls appear only very faintly, if at all. In most sections stained as in the vegetative part they cannot be distinguished. This is true also of the protoplasmic pits, though it is evident there is close communication throughout. From one or two unusually clear sections it was ascertained, however, that the rings are present, but are very small. The cells in this region measure from 25 to 37 mic. long by 2.5 to 7 mic. wide.

Cortex.—The transition from the pith to the cortex is somewhat abrupt. In longitudinal sections the pith cells are seen to decrease in length until in the four or five outermost rows the outline of the cells is spherical or slightly oblong. In the transition zone, or the inner part of the cortex, they measure from 5 to 12 mic. along either diameter.

In the outermost layers of smallest cells, measuring from 2.5 to 5 mic. in diameter, the cell contents are very dense and the cells are apparently imbedded in a gelatinous matrix from which it is impossible to distinguish their walls. In one section, however, the writer was able to make out faint outlines of the walls, but it is difficult to represent them and maintain the proportional thickness of the wall (Fig. 11, Pl. 13).

The cortex cells are seen to lie in communication also, but only along the radial lines of the thallus. The cells are so small no rings can be distinguished, but protoplasmic threads are seen running from cell to cell (Fig. 13, Pl. 13). There are no lateral protoplasmic connections between cells. A surface view of the thallus shows a somewhat regular arrangement of the end cells of these radial rows. They appear as a rule in groups of two or occasionally three, surrounded by the gelatinous matrix (Fig. 14, Pl. 14). If the sections be placed in water this swells rapidly, as do also the cell walls. The walls often increase to three or four times their width, as seen in alcoholic material, and a stratification of the walls becomes evident (Fig. 16, Pl. 14).

Reproductive Organs.

Cystocarps.—The material studied was too far advanced to show antheridia or the development of the cystocarp.

The cystocarps are found scattered very abundantly along the margin and over the surfaces of the fertile fronds. As a rule they are much more abundant upon one surface than the other.

They are borne in leaf-like proliferations of the frond and are usually more or less distinctly stalked, though often they are nearly sessile. Fig. 4 shows one of these leaf-like outgrowths bearing no less than nine cystocarps. Generally the number is smaller, from two to four (Fig. 5, Pl. 13). The larger leaflets, with a larger number of cystocarps, are usually found along the margin.

In form the cystocarps are subglobose with a marked indentation at the apex which seems to indicate a distinct carpostome, but in the large number of sections observed no opening could be detected. The nearest approach to it was seen in the section represented in Fig. 19, Pl. 10, but even here there is no sign of a true pore or even of a rupture, so that evidently the cystocarp is closed. From the uniform closure of the cystocarp it is difficult to include the plant in question with *Gigartina*. The structure of the cystocarp regions of the thallus shows the same two general areas described for the stipe and lamina with the modification of the inner region or pith described above. The spores are developed within the central region, the cortex and outer part of the pith forming a true pericarp. Except at the apex both areas surround the central mass of spores. Here it is covered only by the cortex.

A peculiar structure observed was one in which the surface of the thallus was only slightly raised to indicate its location, and numerous long filaments were seen with their tips protruding slightly from the surface (Fig. 18, Pl. 14). The section was stained with fuchsin and the clear filaments were sharply distinguishable from the other cells with their granular contents. They measured 150 mic. in length.

There was some little doubt as to what should be the interpretation of the section represented in Fig. 18, Pl. 14. The pith cells have the appearance characteristic of the cystocarp region. A comparison with figures in which trichogynes are represented shows but slight similarity in appearance. The pericarp consists of the two layers found in the lamina and stipe. The outer small cells containing chromatophores pass somewhat abruptly to the cells of the interior (Fig. 21, Pl. 14), which are elongated and connected to form a more or less dense net-work. In most cases the transverse connecting cells are more numerous than in Fig. 21, so that the pericarp presents the reticulated appearance of the tissue in Fig. 19. Very frequently, however, the cells show much lateral crowding in the pericarp.

The cystocarp is compound and the spores are aggregated into distinct groups (Fig. 19, Pl. 14). This is clearly seen in all but the oldest cystocarps and even here a carefully cut section shows it. These groups are separated from each other by large, empty cells, with smaller cells of the same character extending between them (Fig. 20, Pl. 14). This is brought out very clearly by staining the section with iodine and then washing in water.

The carpospores are more or less oval in shape, often somewhat angular. They measure from 12 to 15 mic. along one diameter by 10 to 12 mic. along the other.

The normal cystocarps measure from 1 to 2 mm. in diameter, but it was noticed that frequently some were met with from two to three times as large as the ordinary ones, measuring 2.5 to 3.5 mm. On examination it was discovered that the fronds of another small alga were always found upon these large cystocarps. Several specimens were studied and it was found that there was evidently more than one species infecting them. The largest one discovered is represented in Fig. 7 a, Pl. 13. It appears to emerge directly from the apical depression of the cystocarp. A longitudinal section through the cystocarp shows the parasite or epiphyte to consist of an axial cylinder of large cells with protoplasmic connections between adjacent walls. Most externally is a region of quadrilateral cells larger than the corresponding cells of the host arranged quite irregularly, and between this and the central cylinder a region of long filamentous cells, and it is these which are seen to penetrate the pith of the pericarp (Fig. 22, Pl. 14). They can be traced to the central spore-bearing area, where they apparently curve outward and follow along the side a short distance. They are distinguishable from the granular cells of the pericarp by their clear appearance.

In most cases the infecting plant was found to be a smaller one, represented in b Fig. 7, Pl. 13. It consists of simple or branched filaments of oblong cells, but its entrance into the tissues of the pericarp could not be detected. Its presence is evidently the cause of the enlargement of the cystocarp, however. Except in cases where the parasite can be seen within the tissues of the cystocarp no difference except size can be observed between the infested organs and the normal ones.

Nemathecia.—These were found upon only one frond in the alcoholic material at command, but in this they were abundantly distributed on both sides of the frond. They appear in surface view as wart-like projections which can be distinguished with the naked eye by their slightly lighter color (Fig. 8, Pl. 13). (It must be remembered that this description applies to alcoholic material.)

A section of the frond shows many interesting features. The filaments of the internal pith area are even more loosely anastomosed than in the vegetative part of the frond and show large intercellular spaces. In this central area large, dark bodies the size of spores were discovered scattered very abundantly among the filaments (Fig. 24 e, Pl. 14). These could easily be seen from the surface, showing through the external area of cortex cells, and even appear to the naked eye as tiny black dots. Upon examination they were found to be of a dark green color and apparently unicellular. They are evidently internal parasites, but no connection between them and the nemathecia could be discovered, though it was earnestly sought, inasmuch as Schmitz, in his article "Die Gattung Actinococcus Kutz,"* ascribes the nemathecia of *Phyllophora brodiæi* and *P. interrupta* to the parasite Actinococcus.

Outside the central filaments is an area of approximately spherical cells, which decrease gradually in size toward the exterior. They exhibit a characteristic arrangement, *i. e.*, from a single basal cell two and sometimes three rows diverge toward the surface. The outer layer is covered by a thick gelatinous cuticle (Fig. 24, Pl. 14). The tetraspores are evidently produced from the cells just outside the central filaments and are formed in irregular masses just below the surface.

* Schmitz. Flora. 77: 367. 1893.

In many places where there is almost no elevation of the surface a small group of tetraspores is distinctly seen in section. Staining with iodine brings out the distinction between tetraspores and the surrounding cells very clearly.

A peculiar feature of the nemathecia is the pore-like break in the cuticle just above the group of spores. This was seen in even the smallest nemathecia, and in the larger ones several were often present. A full-grown nemathecium rises from 25–37 mic. above the level of the thallus, and an irregularity in the arrangement of the cortex cells is noticeable at the apex, suggesting a rupture as a result of the crowding upward of the spores. The spores measure 12–20 mic. by 10–15 mic.

Wille* makes a physiological distinction between the pith and cortex regions, considering the former as conducting tissue and the latter as assimilative. Some interesting results were brought out by iodine staining in connection with this view.

Sections of the holdfast, stipe, lamina, cystocarp region and nemathecia were placed in an iodine solution for half an hour, then washed with water, with the following results: The holdfast simply shows a general yellowish staining of the cell walls, showing there is no starch present in that region, as would be expected from its evident mechanical function. The stipe likewise showed a slight yellowish staining of the walls, but no cell contents in accordance with its function as a supporting and conducting area.

In the lamina the sections used were longitudinal ones. The central elongated cells remained colorless; in the inner cortex cells marking the transition in shape from the central to the small peripheral cells the contents stained a deep purple, indicating the presence of starch. The four or five outer rows showed the cell contents stained yellowish brown. These are the cells containing chromatophores. These results suggest a confirmation of Müller's interpretation of the physiological significance of this area, inasmuch as they are evidently concerned with the food supply.

In the cystocarp region the outer layers of cells containing rhodoplasts stain yellowish brown as in the lamina; the rest of the pericarp and the spores stain a deep violet, but the thin-walled cells separating the groups of spores stain yellow. This brings out the structure of the central spore region better than any of the other stains used.

* Wille, N. Nova Acta Acad. Leop.-Carol. Nat. Cur. 52: 49–100. *pl. 3–8.* 1897.

In the nemathecia the tetraspores stain a deep violet, as also do the contents of the central filaments just below the spores. The rest of the central filaments remain unaffected and the outer cells stain yellowish brown.

Specific Description.

Gigartina sp. und.—Fronds purplish-red, distinctly caulescent, several often springing from the same disc-like holdfast; 18–28 cm. long by 7–10 cm. wide. Stipe somewhat compressed, 3.5 to 5 mm. wide by 2–3 mm. thick, gradually widening into the typically cuneate lamina. Young fronds often entire, older ones sparingly branched, branches expanded, never linear or lanceolate. Cystocarps compound, closed, more or less stalked, several generally occurring crowded together on the same proliferation; enclosed within a pericarp; 1–2.5 mm. in diameter; carpospores numerous, crowded together in more or less definite groups, oval, 12–15 mic. long by 10–12 mic. wide. Tetraspores produced in nemathecia, on both sides of the frond; nemathecia wart-like, rising 25–37 mic. above the level of the thallus. Tetraspores oval, more or less angular, 12–20 mic. long by 5–10 mic. wide.

Methods.

Part of the sections used were cut with the freezing microtome, the rest by hand. The material used had been preserved in 75 per cent. alcohol. The effect of imbedding in gelatine prepared according to Osterhout's directions was tested. The portions to be sectioned were cut in* pieces .5 cm. long and about the same width and placed in the gelatine. This was left for twenty-four hours to allow the gelatine to penetrate the tissues, then removed and placed in a gum arabic solution on the freezing chamber. After several trials it was found that sections introduced directly into the gum arabic without embedding were as satisfactory as by the longer process.

Staining.—At first water solutions of the stains were used, but it was found that this caused the tissues to swell to such an extent that cells often presented a very unnatural appearance. For example, a cross section of the stipe was obtained in which the cell lumen appeared irregulary star-shaped or was nearly obliterated (Fig. 16, Pl. 14). This was then abandoned and

* Osterhout. Bot. Gaz. **21**: 195–201. 1896.

alcoholic solutions were used. Both staining the sections and the material in toto were tried. In the latter method, if the material was to be imbedded, it was first stained. If the stain is sufficiently diluted, and the sections are allowed to stand in it from ten minutes to half an hour, the results are quite as satisfactory as staining in toto, for in the latter method often the stain fails to penetrate the material completely.

The stains employed were hæmatoxylin, anilin blue, methyl blue, carmine, methyl violet, fuchsin and safranin. Hæmatoxylin stains both cell wall and contents, but not clearly enough; it was found very unsatisfactory. Anilin blue and carmine hardly affected the tissues. Methyl blue and safranin proved good for the gelatinous sheath. Methyl violet and fuchsin gave the most satisfactory results. They stain both the cell walls and protoplasmic contents, but the latter more deeply. These two stains, and especially fuchsin, were used for all the work.

The sections were at first taken from the knife and placed in glycerine, transferring gradually from 20 per cent. to absolute, but the glycerine was found to swell the cell walls to a considerable extent and was abandoned.

The most satisfactory method and the one employed in all the latter part of the work was as follows: The alcoholic material was placed directly in the gum arabic solution on the freezing chamber, transferred from the knife to the alcoholic solution of the stain and mounted in it. When the staining was completed, usually after a few moments, the sections were washed in alcohol. This was then evaporated and, without allowing the sections to become dry, glycerine jelly was added, making a permanent mount.

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Explanation of Figures in Plates XIII. and XIV.

All drawings were made from material preserved in alcohol.

Fig. 1. Group of fronds springing from a common holdfast. One-half natural size.

Fig. 2. Upper portion of fertile frond showing marginal and surface proliferations with cystocarps produced upon them. One-half natural size.

Fig. 3. Young frond showing typical shape and single holdfast. One-half natural size.

Fig. 4. Small leaflet with cystocarps. x 4.5.

Fig. 5. Four cystocarps on a small stalk-like proliferation. x 4.5.

Fig. 6. Surface view of holdfast showing scars. x 4.5.

Fig. 7. Cystocarps infected by a parasite. x 5.

Fig. 8. Surface view of nemathecia. x 5.

Fig. 9. Section through a scar of the holdfast: *a*, layer of cuticle on upper surface; *b*, region of the lower surface covered with cuticle; *c*, rough broken lower surface. x 5.

Fig. 10. Section through the holdfast with rhizoid-like outgrowth from the lower surface. A portion of the tissue is omitted in the center, as it issimply a continuation of that represented on either side. Toward the left the drawing stops in the stipe region. On the right the transition from the stipe to the holdfast is shown: *a*, cuticle of upper surface; *b*, region showing cellular structure characteristic of the holdfast; *c*, cellular structure marking transition from tissue of holdfast to that of stipe; *d*, beginning of tissue of the stipe; *e*, curvature of cells at juncture of stipe and holdfast. x 300.

Fig. 11. Longitudinal section of the lamina: *a*, cortex; *b*, outer region of pith showing larger pith cells; *c*, inner region of pith with smaller cells. x 300.

Fig. 12. Cross section of stipe: *a*, cortex; *b*, larger celled pith; *c*, smaller celled pith. x 300.

Fig. 13. Cross section of the lamina showing many pith cells connected by pits and cortex cells connected by protoplasmic threads. x 300.

Fig. 14. Surface view of thallus. x 300.

Fig. 15. Outline of cross section of stipe showing cortex and pith areas. x 4.5.

Fig. 16. Pith cells of lamina stained with methyl violet and mounted in glycerine. Cell wall is much swollen and one shows stratification. x 300.

Fig. 17. Effect of sulphuric acid on cell wall and pits; *a*, pith cells treated for ten to fifteen minutes in 50 per cent. solution; *b*, pits as seen twenty-four hours after treating the section with the acid. The walls have been entirely dissolved. x 300.

Fig. 18. Cluster of filaments. x 300.

Fig. 19. Longitudinal section through a cystocarp. x 85.

Fig. 20. Group of spores from cystocarp with thin-walled cells separating them. x 300.

Fig. 21. Longitudinal section through the pericarp: *a*, cortex; *b*, pith; *c*, spores. x 300.

Fig. 22. Longitudinal section through an infested cystocarp. The upper left-hand portion shows the manner in which the parasite penetrates the host. x 56.

Fig. 23. Portion of the same region enlarged showing to the left the tissues of the host pericarp and to the right the long filamentous cells of the parasite. x 300.

Fig. 24. Section through frond producing nemathecia. On the upper surface is a mature nemathecium, on the lower surface two two younger ones: *a*, gelatinous cuticle; *b*. pore-like break in cuticle; *c*, cortex cells; *d*, cells from which tetraspores are produced; *e*, parasite; *f*, pith filaments. x 300.

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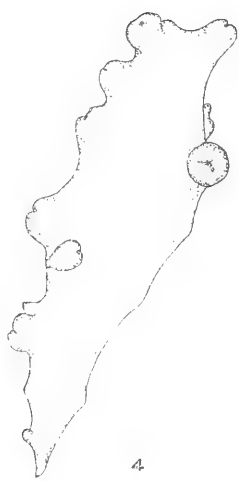

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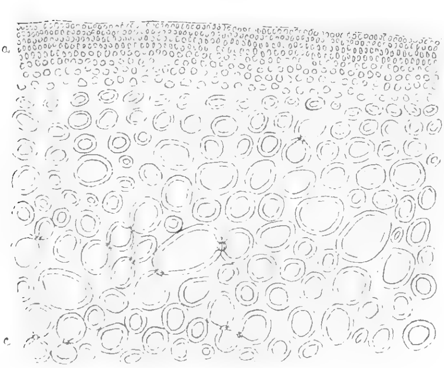

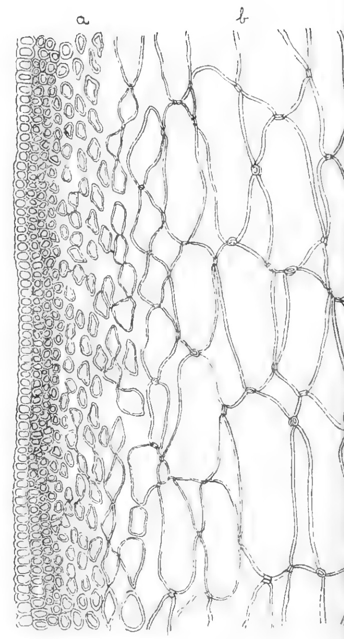

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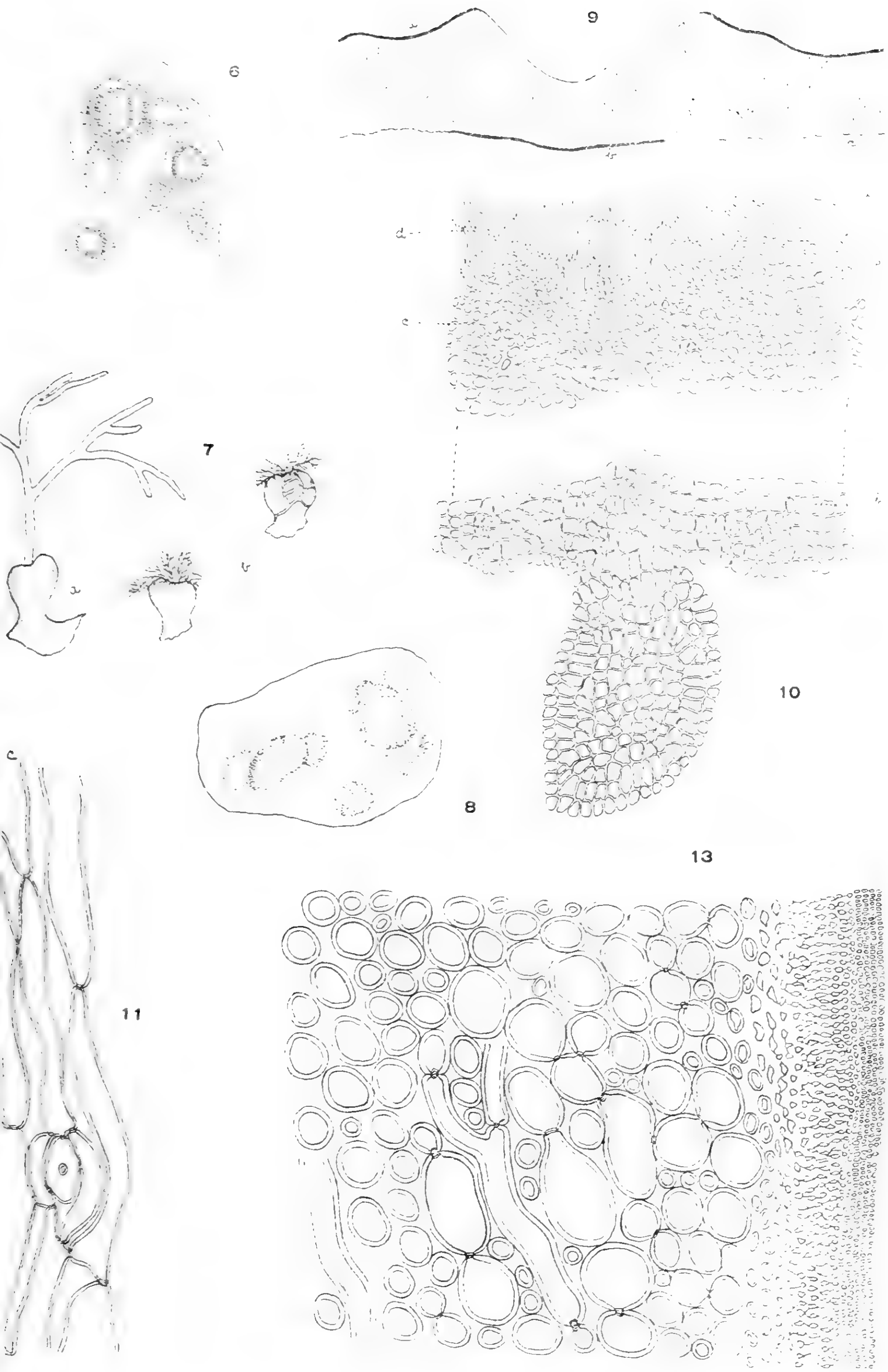

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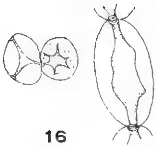

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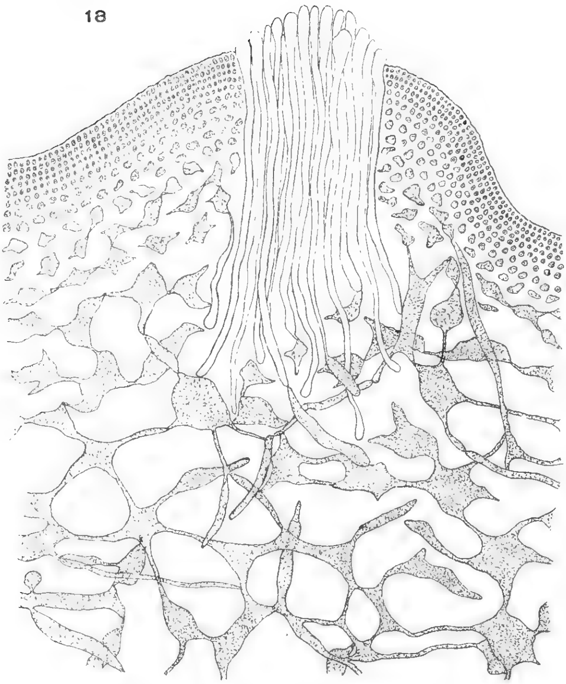

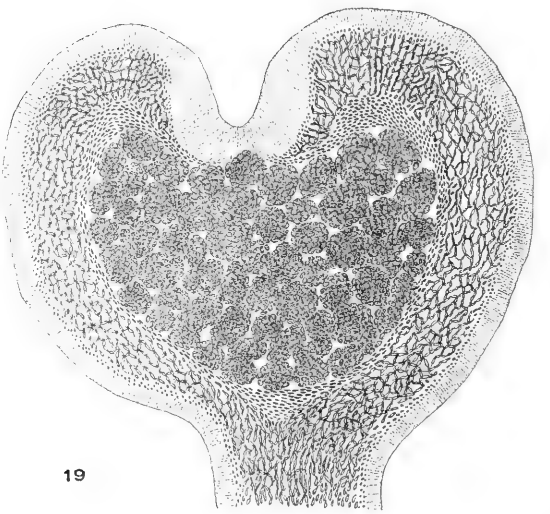

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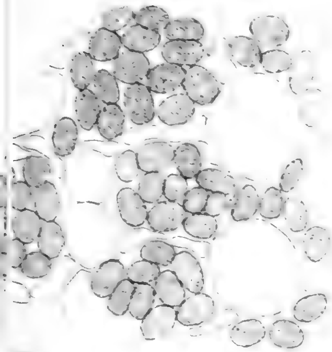

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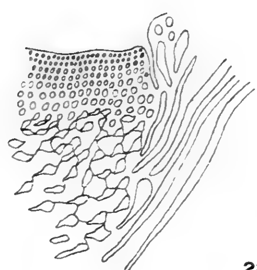

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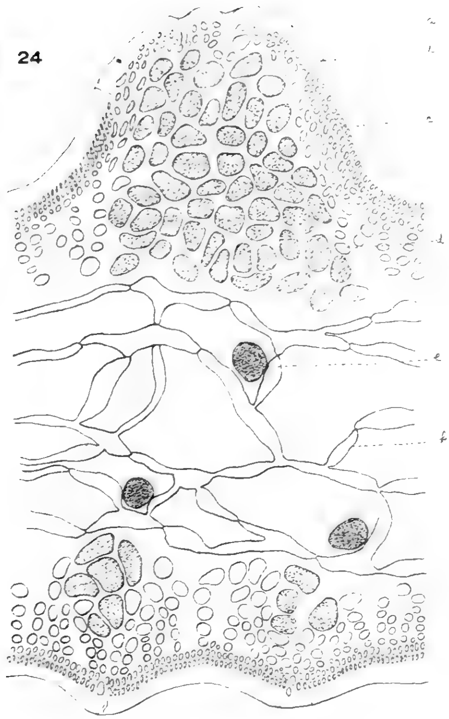

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XII. SEED DISSEMINATION AND DISTRIBUTION OF RAZOUMOFSKYA ROBUSTA (Engelm.) Kuntze.*

D. T. MacDougal.

The branches of the bull pine (*Pinus ponderosa scopulorum*), of the southwestern United States, offer suitable conditions of nourishment for the growth of *Razoumofskya robusta*, a parasite belonging to the Loranthaceæ. Some of the members of this family, such as the mistletoe (*Phoradendron flavescens*), which live on deciduous trees in temperate latitudes, are furnished with a fair amount of chlorophyll. These forms are able to carry on more or less food-formation during the warmer portions of the season in which the deciduous hosts lack leaves. *Razoumofskya*, however, fastens on an evergreen conifer, and hence has no such need or use for chlorophyll. It is, therefore, furnished with this substance in minute quantity only, and its leaves are reduced to mere bracts. It is diœcious, and the aërial shoots of both kinds may appear in close contiguity on the same branch of the host or be separated some distance. The shoots start up from the submerged rhizomes in the latter part of April or early in May, the flowers maturing in June and the seeds in August. After the dispersal of the seeds the aërial portion of the plant dies away, leaving only the haustorial rhizomes buried in the tissues of the host plant. With the opening of the next season shoots are produced as before.

The submerged portion of the parasite penetrates the branches of the host long distances longitudinally, and where aërial shoots are given off the tissues of the host show abnormal structures, the branches undergoing enlargement, while the development of the nearest buds is variously checked and altered. The distortion is magnified with age, and old trees exhibit the most grotesque malformations. The writer has seen trees a meter in height infected, and the size of the older branches bearing the

*An abstract of this paper was read before the Botanical Club of the A.A.A.S. at Boston, August 25, 1898.

parasite is such as to justify the statement that they may live ten to twenty years after the parasite has fastened upon them. A common type of structure resulting from the attachment of the parasite to the pine consists of an old branch bent downward, from the infected tip of which numbers of smaller branches stand erect, forming a coarse "witch's broom" (See Plate XVI.).

Perhaps the most interesting facts in connnection with the history of *Razoumofskya*, are those which concern the distribution of the seeds. The single-seeded berries are borne on short stalks curved semi-circularly, from which they are easily detached when ripe. The berry is joined to the stalk by a scission layer, which is ruptured by the slightest touch or may be burst away by the action of forces set up in the berry, which also expel the seed. The shooting of the seeds from the berry has been known for many years, and a note of the fact has found place in American text-books of systematic botany, but it has failed of wider recognition. Engler and Prantl remark concerning the seeds of the Loranthaceæ: "The stickiness enables some seeds falling from branch to branch to become attached; on the other hand, birds crush the fruits and discard the seed, which is surrounded by a viscid layer." (Naturlichen Pflanzenfamilien. Theil III.) Kerner says: "The dissemination of the European mistletoe is effected as in all Loranthaceæ through the agency of birds, thrushes in particular, which feed upon the berries and deposit the undigested seeds with their excrement upon the branches of trees." (Nat. Hist. of Plants, I: 205, 1894.) Keeble, the most recent observer who has published upon the Loranthaceæ, says: "The berry-like fruits of the Loranths are technically speaking indehiscent; yet owing partly to growth of the embryo, partly to weakening of the fruit wall in some species, this latter becomes ruptured on the ripening of the fruits, *e. g.*, *Loranthus neelgherrensis L. cuneatus;* in others a very slight pressure is sufficient to cause the complete extrusion of the seed, sometimes basally, sometimes apically. In all cases the seed slips out, but in *Viscum orientale* Willd., a gentle pressure will cause the fruit wall to crack and the seed to be jerked out." (Observations on the Loranthaceæ of Ceylon, Trans. Linn. Soc. Lond. 2nd Ser. Bot. 5: Pt. 3, p. 97, 1896.)

In view of the above statements it is safe to conclude that *Razoumofskya* is the only Loranth furnished with a mechanism for the expulsion of the seeds from the berries without the intervention or coöperation of outside factors. The expulsory mechanism is best seen in a longitudinal section of the berry. The base of the berry is joined to the stalk by a scission layer several cells in thickness. The outer coat is firm and smooth, and is composed of an epidermal layer with the outer wall extremely heavy and cuticularized. Beneath the epidermis is a mass of parenchymatous tissues, the outer portion of which is slightly palisaded and containing chlorophyll, the inner layer showing only starches and sugars. Immediately internal is the fibrovascular framework which fuses at the apex in a solid mass of mechanical tissue. Lying inside the fibrovascular strands, and continuous with the parenchymatous tissue external to it is also a mass of similar thin-walled elements of ovoid or cylindrical form rich in carbohydrates. These cells have their axes at right angles to the surface of the berry. The second layer internal to the fibrovascular tissue is the expulsory layer, consisting of very long thin-walled cylindrical tubes with their axes parallel to the long axis of the berry at the apex of the seed or variously inclined from this position according to the location, but all so arranged that their longitudinal expansion would tend to force the seed out of the mouth of the sac formed by the berry. Immediately coating the seed is a layer of globoid cells with thick mucilaginous contents. The seed has the form of a modern rifle bullet, conical at the basal end and truncate at the apical end, with a general cylindrical outline. The scission layer appears to cut into the mucilaginous layer or at least very nearly so in the mature berry. During the ripening period the contents of the expulsory layer undergo such chemical changes as to give the contents a very high isotonic coefficient. The consequent osmotic attraction of water into this layer sets up a turgescence which could not be measured, but which probably amounted to many atmospheres. The steady increase of the turgidity of the expulsory layer brings the tension to the breaking strain of the scission layer, and its sudden and complete rupture permits the full force of the pressure to act upon the seed, sending it to a distance of two or three meters. The entire arrangement is that of a mortar cannon.

The muzzle of the gun is sealed by the stalk, and the charge amounts to several atmospheres, which is allowed to act upon the seed when the muzzle is freed. The firing of this unique gun may result from the overcoming of the resistance of the restraining layer at the muzzle, or this event may be precipitated by any force from the outside which would result in the disturbance of the scission layer. One may stand under a pine tree on a quiet morning and hear the sharp click accompanying the expulsion of the seed from the berries at irregular intervals. If the branches are jarred or shaken, however, the irregular explosions give way to fusillades by which nearly all of the berries on a plant will be set in action at once.

The expulsion of the seed occurs as soon as the berry has broken loose from the stalk, and as these berries were originally in all positions the seeds are sent out in all directions. The mucilage adhering to the seed causes its attachment to the branches or other bodies it may strike. In this manner dissemination is effected throughout a cylindrical space about seven meters in diameter and extending downward to the ground. The only localities which offer suitable conditions for the germination and growth of the seeds, however, are the tips of branches or the shoots of young trees underneath. It is to be seen that no animals are to be found in the habitat of the parasite which would in ordinary usage carry the seeds to these locations. The only part, therefore, that animals play in the dissemination of the seeds would be in causing the discharge of the berries, a matter of no direct value, since they are capable of quite as efficient action independently. The berry of *Razoumofskya* is, therefore, to be classed as a sling fruit, and is probably the only one of this class from the United States which has been described, though many doubtless exist.

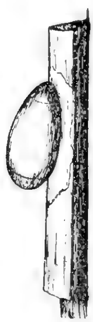

FIG. 1.
Seed of *Razoumofskya* adhering to pine leaf.

A second point of interest in this plant consists of a fact bearing upon its local distribution. During the course of some recent field work in northern Arizona the writer found that *Razoumofskya* was most successful in its attacks on the pine trees along the rims of cañons or along the brows of hills or margins of mesas. A study of the meteorological conditions shows that this method of distribution has a direct connection with the vertical movements of the air.

As the air resting on lowlands in cañons or valleys is warmed by radiation during the time of exposure to the sun's rays, it rises and expands. During the ascent some heat is converted into the work necessary in expansion, causing a cooling of one degree Fahrenheit for every one hundred and eighty-eight feet of elevation. The decrease in temperature lowers the dew point or increases the relative humidity, a matter of very great importance to germinating seeds and transpiring leaves. *Razoumofskya* is especially abundant, precisely at the places where the effect of the ascending humid currents of air is greatest, along the margins of hills and mesas and the rims of cañons. This is very noticeable along the Grand Cañon of the Colorado river, in the Coconino Forest reserve, where the air rising more than a vertical kilometer from the river bed pours across the pine-covered mesa at a much lower temperature and very much nearer the dew point than the body of air which it replaces. In its rise it has lost heat at the normal adiabatic rate to the amount of about twenty-five degrees F., and has undergone a great variation with respect to the dew point. As a consequence of the increased humidity favorable to germination, the pines near the rim of the cañon are most thickly infested with the parasite over a belt one to four or five kilometers in width running parallel to the margin. One may walk through the forest and note the decreasing abundance of *Razoumofskya* as the distance from the cañon increases.

In recapitulation of the facts adduced in this note it is to be said that the berries of *Razoumofskya* are to be classed as sling fruits, the only one from North America hitherto described, and that this genus is the only one of the Loranthaceæ furnished with means of seed-dissemination independent of gravity and animals. The writer also believes that he is justified in announcing the discovery of the influence of vertical air-currents upon the distribution of plants, and that this factor must be taken into account in the consideration of the boundaries of zones in mountainous regions or those with irregular topography.

Explanation of Plates.

Plate XV. D. Staminate plants of *Razoumofskya*. B. Pistillate plants with mature berries. The distortion of the branch of the host is plainly shown.

Plate XVI. A. *Pinus ponderosa* dying from the effects of the parasite, photograph of a specimen growing on the extreme edge of the rim of the Grand Cañon of the Colorado, June, 1898. C. Specimen of *Pinus ponderosa* showing drooping of branches attacked by *Razoumofskya*.

PLATE XV

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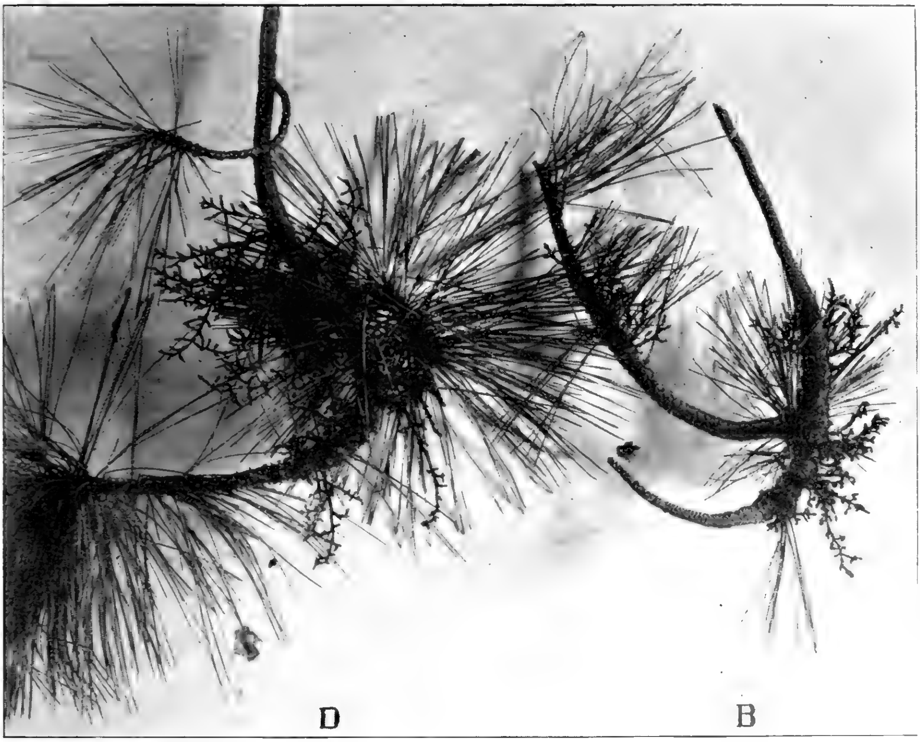

PLATE XVI.

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XIII. OBSERVATIONS ON CONSTANTINEA.

E. M. Freeman.

History and Literature.—The earliest mention of the red seaweed now classified under *Constantinea* is found in Gmelin's* *Historia Fucorum* published in 1768, in which he describes *Fucus rosa-marina* from the material collected by G. W. Steller during the years 1742–1745 at Kamtschatka. The description is as follows: "Peculiare sistet hæc planta fuci specimen, cujus exemplum aliud in omni reliqua fucorum historia non occurrit. Caulis teres est, carnosus, pennæ anserinæ crasitie, ramis sibi similibus, quibus, tanquam totidem pendiculis, adplicantur verticillatim folia petaloidea terna vel plura, rotunda, concava, circulo in centro notata, pulchre expansa, plerumque sissa, ramo per illa penetrante, exeunte, et pollicis dimidii intervallo nova fronde priori simili, prolifico, tertia nunnunquam pari ratione accedente. Petala convoluta pulchre repræsentant flores polypetalos, ut Rosam, anemonen, cet. Substantia tota gelatinoso-membranacea, aqua dissoluenda, pellucida. Color e rubro flavescens. Magnitudo semipedalis. Locus. Circa Lapatka inter spongias ad Kamtschatcam occurrit."

Such terms as "petala convoluta," "flores polypetalos," etc., show what a profound impression the superficial resemblance of the described plant to a rose had made upon the author.

In the years 1826–1829 the Russian vessel Seniavin, Fr. Lütke, Captain by the order of Czar Nicolaus I., sailed through Russian waters and collected a large amount of valuable algological material. The results were published in 1840 by Postels and Ruprecht in their *Illustrationes Algarum in itinere*, etc. The authors in their preface to this work state that the collections of H. Mertens and the plates of Alex. Postels form the basis of the entire work. The genus *Constantinea* is here described, founded upon Gmelin's *Fucus rosa-marina*, and three species are recognized, *Constantinea rosa-marina*, *C. sitchensis* and *C. reniformis*.

* Gmelin, S. G. Hist. Fuc. 102. *pl. 5, f. 2, 2a.* 1768.

According to the descriptions the first two species of *Constantinea* differ in the length of stipe between annuli, the mode of branching of the stipe and in the nature of the edge of the frond. The following are also noted: *Constantinea rosa-marina* is the smaller (one-half foot or less); branched even to the base; terminal frond two inches in diameter, laciniate (laciniæ 3–6), rarely remaining entire; 2–4 laminæ under the terminal one laciniate in a similar manner. *C. sitchensis* has solitary terminal fronds at the apices of the branches; the fronds are 4–6 inches in diameter, entire but laciniate when older; young fronds are often 8 lines in diameter.

In these supplementary descriptions all differences are compromised except the following: length of the "internode" of the stipe; the number of fronds on each branch; the method of branching of the stipe and the difference in size. The tetraspores of *C. sitchensis* alone are described. The "gongyli rotundi" as Kützing* has since pointed out are but ordinary cells of the intermediate layers of the frond. Postels and Ruprecht also mention *Constantinea reniformis*, a rare Mediterranean plant supposedly of this genus.

In 1843 Zanardini† described the *C. reniformis* of Postels and Ruprecht under the name of *Neurocaulon foliosum* from material collected on the shores of Dalmatia in the Adriatic. In the same year Kützing‡ called attention to the incorrect view of Postels and Ruprecht concerning the "gongyli rotundi" and to the great similarity in vegetative structure but great difference in outward appearance and tetraspore formation between *Constantinea* and *Euhymenia*. He describes the tetraspores and states that the cystocarps are unknown. His statements are evidently based solely on Postels, and Ruprecht's observations.

In *Species Algarum*, 1849,§ the two arctic species of Postels and Ruprecht are described under *Neurocaulon* as *N. rosa-marina* and *N. sitchensis*.

Two years later J. Agardh ‖ accepts the Postels and Ruprecht generic name of *Constantinea* and adds to the previous description of the vegetative parts and tetraspores that of the cysto-

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* Kützing. Phyc. Gen. 400. 1843.
† Zanardini. Saggio class. 49. 1843.
‡ Kützing. l. c.
§ Kützing. Spec. Algar, 744. 1849.
‖ Agardh, J. Spec. Gen. et Ord. Algar. **2**: 295. 1851.

carps. Since no new observations nor collections of the arctic species are cited, his generic description of the cystocarp is probably based upon *Constantinea reniformis*, the Mediterranean species. The cystocarps are described as "kalidia in media fronde numerosa, clausa, disruptione partis ambientis demum liberata, nucleolis pluribus composita; nucleoli intra periderma gelatinosum hyalinum gemmidia, nullo ordine disposita foventes." The zonate division of the tetraspores is noted. The collections of *C. reniformis* cited are: In the Adriatic sea on the shores of Dalmatia (Meneghini! and Zanardini!) and in the Mediterranean sea at Cette (Salzman!) and at Marseilles (Solier!). Nothing new is added concerning *C. sitchensis* and *C. rosa-marina*, but *C. reniformis* is fully discussed. The latter had been collected also by Mertens and described by him under the name of *Kalymenia reniformis*. In 1822 it was described by Agardh * under the name of *Halymenia reniformis*, and Postels and Ruprecht † describe it as a third species of *Constantinea*—*C. reniformis*. In 1822 J. Agardh ‡ stated that the tetraspores of *C. reniformis* had not been found.

Harvey's description of *Constantinea* in 1858 § is based upon the observations and literature cited above. The similarity in structure and the difference in external form and in position of tetraspores is noted. The branching of the stipe is described as at first irregular but later dichotomous; the dichotomy, however, is often lost in the abortion of one branch.

In 1862 in a notice of a collection of algæ made by Dr. David Lyall at Vancouver Island in the years 1859–1861, by W. H. Harvey‖ specimens of *Constantinea sitchensis* with torn laminæ which were probably six to eight inches in diameter when perfect were reported "adrift on the beach at Victoria harbor." And Harvey observes that "perhaps this is only a luxuriant state of *Constantinea rosa-marina*."

In Kützing's work of 1867¶ the genus is again described under *Neurocaulon* and *N. foliosum* and *N. rosa-marina* are mentioned. The work of Postels and Ruprecht is not cited.

* Agardh. Spec. Alg. 201. 1822.
† Postels and Ruprecht. Ill. Alg. 17. 1840.
‡ Agardh, J. l. c.
§ Harvey, W. H. Nereis Boreali-Americana **2**: 173. 1853.
‖ Harvey, W. H. Journ. Proc. Linn. Soc. Bot. **6**: 172. 1862.
¶ Kützing. Tab. Phyc. **17**: 24. *pl.* 83. 1867.

Mention is again made of the genus by J. Agardh in 1876.* He had seen specimens of *C. rosa-marina* from the Museum of St. Petersburg and also a plant from Californian shores which he referred to *C. sitchensis;* but on account of inability to satisfy himself as to the structure of the fruiting bodies he based his descriptions upon those of Postels and Ruprecht.

In 1885 *Constantinea thiebauti* was described by Bornet† from a single specimen collected at Majunga on the north coast of Madagascar. Bornet very properly calls attention to the remarkable range which this genus, with the addition of his new species would enjoy: *C. rosa-marina* and *C. sitchensis* in arctic seas, *C. reniformis* in the deep waters of the Mediterranean and *C. thiebauti* in the tropical waters of the Indian ocean.

In 1891 there appeared in the Botanical Magazine of Tokyo "Remarks on some algæ from Hokkaido"‡ in which *Constantinea sitchensis* Post. and Rupr. (?) is mentioned, but the position of the described plants in the genus *Constantinea* is admitted to be doubtful.

In "Die Natürlichen Pflanzenfamilien" § the genus undergoes rearrangement. *C. reniformis* is restored to the genus *Neurocaulon* of Zanardini, where probably should also be placed Bornet's *C. thiebauti*. The reproductive bodies, as well as the vegetative structure of *C. rosa-marina* and *N. foliosum*, had been studied personally by Schmitz.‖ The classification of Schmitz and Hauptfleisch includes under *Constantinea* the species *C. sitchensis* and *C. rosa-marina* and under *Neurocaulon* the single species *N. foliosum*. I have no certain knowledge as to whether Schmitz had or had not in possession any material of *C. sitchensis*.

Collection.—In August, 1897, and again in the summer of 1898 collections of a species of *Constantinea*, reported as *C. sitchensis*, were made by Miss Josephine E. Tilden, and it is upon this material that the following observations are based:

On August 3, 1897, specimens of *C. sitchensis* were found

* Agardh, J. Spec. Alg. 3: 225. 1876.

† Bornet. Alg. de Mad. Bull. Soc. Bot. de France 32: 18. *f. 1. 2.* 1885.

‡ Okamura, R. Remarks on some algæ fron Hokkaido. Bot. Mag. Tokyo. 5: 333–336. 1891.

§ Schmitz and Hauptfleisch. Nat. Pflanz. I. Teil. Abt. 2: 517, 519, 520, 525. 1897.

‖ Schmitz. Sys. Übers. der bisher bekannten Gattungen der Florideen. Flora 72: 436. 1889.

growing upon holdfasts of *Nereocystis lütkeana* in 8 fathoms of water at Channel Rocks, near Seattle, Washington. During the summer of 1898 large collections were made at many of the stations where Dr. Lyall collected in 1859–1861. Collections were made at the following places: (1) Fairhaven, Washington. May 25. Washed up on the beach. (2) Near Minnesota reef, San Juan island, Washington. June 5. Attached to stones on a flat, sandy beach. This and the three following were found just below lowest tide. (3) Near Friday Harbor, San Juan island, Washington. June 5. Attached to rocks on rocky, steep beach. (4) Oak Bay (a suburb of Victoria), British Columbia. July 1. On a sandy beach. (5) Esquimalt, British Columbia. July 2. Attached to rocks. The first and last two collections contained abundant tetraspore material.

Preservation.—The material collected in 1897 was killed and preserved in 80% alcohol. Owing to the small amount of this material and to the better condition of that collected in 1898, all of the following drawings except Fig. 1 have been made from the 1898 material. The larger part of it was killed and preserved in a 2 per cent. formalin solution in sea water. In this the color was very well preserved. The firmness of the tissues, however, suffered considerably more in the formalin-solution material than did that of the alcohol material of 1897. The formalin material was still sufficiently firm to admit of very satisfactory manipulation. Still other plants were preserved in camphor water, and some in 1 per cent. chromic acid solution. The camphor material lost its color almost as completely as the alcoholic. It preserved, however, a great firmness, which rendered the tissues excellent for section cutting, and especially for hand sections. The gelatinous cell walls, however, were so cleared that they were not as easily defined as in the formalin material. The chromic acid collections were in a poor state of preservation; the tissues were very soft, the cell walls almost invisible and the contents usually, at least partially, disorganized.

Methods.—Various methods were employed in cutting the tissues. A part of the material was transferred directly from water to 20 per cent. glycerine, thence to a gum arabic solution upon an Osterhout freezing chamber.* Material was sometimes placed directly from the sea water on the freezing chamber

* Osterhout, W. J. V. Bot. Gaz. 21: 195. 1896.

with results almost, if not equal, to those obtained when it was passed first into 20 per cent. glycerine. When the sections were removed from the knife they were placed in 20 per cent. glycerine, and from this into 50 per cent. and then into absolute glycerine; or from 20 per cent. glycerine to water and then through the alcohols to an alcohol stain or directly into a water stain. The freezing device mentioned above proved very satisfactory in many respects. The tissues can be frozen in a minute's time, are held firmly in place, and the gum arabic, when of the proper consistency, is an excellent imbedding medium. The difficulty experienced with this method of cutting such delicate tissues as are found in many of the seaweeds lies in the handling of sections after they are cut. Especially is this true when it is desirable to stain the sections and when they must be transferred through several per cents. of alcohol and glycerine. With such tissues as are found in the frond of *Constantinea*, where they part with great ease, the difficulty is augmented, and it was found almost impossible to preserve thin sections whole. An attempt was made to obviate this difficulty by mounting the sections directly from the microtome knife into glycerine jelly at a temperature sufficient to keep the jelly semi-fluid. This was in part an improvement, but necessitated the mounting of many worthless sections. When sections unstained were mounted in glycerine or glycerine jelly, the great transparency of the swollen cell walls added a new difficulty.

Material was also passed into paraffin and stained on the slide and mounted in Canada balsam by the usual methods. Extreme care was found necessary, on account of the delicacy of the tissues, to make the stages from one fluid to another by very gradual changes. I was unable to prevent a partial shrinkage of the cell contents. Sections by this method were otherwise quite satisfactory, having the advantage of use in serial work. Staining is necessary in this method since the sections become almost invisible in Canada balsam.

Sections cut freehand with a razor or in a hand microtome with the material imbedded in pith have furnished most of the material from which the accompanying plates are drawn. Sufficiently thin sections were obtainable in this way with the great advantage of certainty as to the normal condition of the tissues and of speed in preparation. A large number of such sections can be cut and preserved in 2 per cent. formalin for a long time and are ready for use at any moment.

A number of staining fluids were used, section staining, either on or off the slide proving more satisfactory than staining in toto. Aniline stains were used almost exclusively. The following were employed with at least some degree of success:

Aniline blue: Stains the gelatinous wall of the cells pale blue, the chromatophores of the cortical cells deep blue and the contents of the tetraspores and of the paraphyses light blue. The central part of the pyrenoids of the endophytic alga which is usually present in these collections takes on a light blue. The best results were obtained with a 40 or 60 per cent. alcoholic solution, acting from 24 to 36 hours. For sections on the slide 5 to 10 minutes in a strong 60 per cent. alcoholic solution was usually sufficient. My best staining results were obtained from aniline blue.

Methylen blue: Stains the cell walls, especially the outer portions, which become quite clearly defined. Sections were stained in a strong 95 per cent. alcoholic solution from 5 to 10 minutes.

Fuchsin: Best results were obtained from sections left in a 10 per cent. alcoholic solution 36 hours. The gelatinous walls were stained light red while the protoplasm of the paraphyses and chromatophores of the cortical cells took up a deep carmine red.

Delafield's hæmatoxylin: Same strength and time as fuchsin. The granular contents of the cells are stained a reddish purple.

Several other stains were used, but without success. In a weak solution of iodine in potassium iodide the granules of the cells of the middle and intermediate layers assume at first a yellowish-brown tinge which finally deepens to an amethyst purple. Stained in a strong solution for a few moments these areas take on a dense violet color.

Gross Anatomy.—In general form *Constantinea* presents several interesting peculiarities. (Figs. 1–6.) The plant is differentiated into a cylindrical stipe and peltate frond at its summit. It is of a purple-reddish color, stands upright in the water below lowest low tide mark, and the texture is quite firm and brittle. It is somewhat gregarious in habit. The stipe is "terete, branched, ringed and the apex of each branch expanded into an orbicular peltate lamina; stipe 1–4 mm. in diameter, 2–8 cm. in length; lamina 2 cm.–3 dcm. in diameter." (Tilden, Am. Alg. no. 203. 1897.) The laminæ have numerous minute dark brownish spots on their upper surfaces. The older fronds are irregularly perforated with circular holes and are more or less torn at the edges (Fig. 3). When young the fronds are entire (Fig. 2). As the plant continues its growth the stem pushes up through the center of the frond, forming a new growing point which elongates into an internode and soon forms another frond at its summit. The old frond then falls off, leaving an annulate marking on the stipe (Figs. 5, 6). There is often, especially in the youngest portions of the oldest plants, a formation of two growing points at the center of each lamina giving rise to a dichotomy of the stipe (Fig. 5). Irregularity in the development of these growing points gives rise to an irregular system of branching (Fig. 5). Growing points are not confined to the bases of laminæ but may be found occasionally arising from other portions of the stipe. There are often a group of small branches formed upon the holdfast (Fig. 1). The latter is a disc-like body arising as an expanded portion of the stipe at its base and usually concave below (Fig. 22).

Upon the lower surface of the fronds especially the larger ones, can be seen distinct radial striations caused by small ridges running from the region near the stipe toward the edge of the frond (Fig. 4). These mark the course of bundles of elongated narrow filaments (see below). The nemathecia which bear the tetraspores are found only on the lower surface of the frond. They occur more abundantly on the larger fronds and are often so numerous as to almost completely cover the under surface. They form small wart-like bodies of whitish color and gelatinous consistency.

Minute Anatomy.—As is well known the thallus of the red seaweed is a group of dichotomously branching filaments whose fused branches form tissue-like areas. In *Constantinea* this method of branching can readily be seen in the frond but particularly so in the cortical area of the stipe (Fig. 18).

Frond.—A cross section of the frond shows three areas of cells: (*a*) a central layer of loosely woven filaments; (*b*) an intermediate layer of large approximately spherical cells stuffed with starch granules (Fig. 7); (*c*) a cortical layer of pseudo-parenchymatous cells.

a. There are in the central area filaments of large cells, usually slightly elongated, often stretching across the frond and perpendicular to the frond surface (Fig. 11). These cells approach the large cells of the intermediate layer in form and size, transitional stages between them being abundant (Figs. 8, 9, 10). Their average size is 55 mic. x 12 mic., but they may attain 75 x 16 mic. A cross section of the lower part of the frond, tangential to its orbicular outline, shows in the central area at more or less regular intervals corresponding to the external striation on the lower surface of the frond, a number of bundles of greatly elongated cells, woven into strengthening bundles (Figs. 7, 8, 9). In the lower region the general course of these bundles is radial in the frond. Divergence from this course is found in the upper part so that a tangential cross section of the frond shows some of these bundles in longitudinal or oblique section (Fig. 9). These filaments are articulated; the cells often attain a length of 325 mic. They average about 8 mic. in breadth. Thin sections of the frond often contain clean-cut circular spaces where the bundles of elongated cells have been pulled out, showing the compactness of the bundles and indicating for it a strengthening function. The bundles vary in size; the striations on the lower surface of the frond mark only the largest bundles.

b. The typical cells of the intermediate area are spherical and average 46 mic. in diameter. They are packed with Floridian starch granules which turn brownish with a weak KI solution of iodine and finally purple or violet in a strong solution. Those cells toward the surface of the frond contain ordinarily a few chromatophores, usually in the end near the surface. The cells of the intermediate layer shade off towards the surface into the cortical cells.

c. The cortical cells are characterized by a compact pseudoparenchymatous grouping in which the long diameters of the but slightly elongated cells are perpendicular to the frond surface. Many of the cells are approximately cylindrical or prismatic. The external layer is of a sufficient regularity in structure and form to recall forcibly an epidermal layer. In these the outer wall is rounded. The cells of the cortical layer contain but a small amount of starch, and this is found in the cells adjoining the intermediate layer. Chromatophores are, however, abundant and more numerous toward the frond surface. Almost all of them are to be found in the first three or four rows of cells from the surface (Fig. 10), but some are found in still deeper layers. They occupy, in the great majority of cases, a position in the peripheral end of the cell. Under the microscope they appear finely rose-colored pink with perhaps a purple tinge. They are irregular in outline, apparently in most cases assuming such a shape as will allow them to occupy the peripheral end of the cell to best advantage. The epidermal cells average about 13 x 5 mic. and the chromatophores about 10 x 2 mic.

Stipe.—(Figs. 14–21). A cross section of the stipe shows a similarity in structure to that of the frond. The same areas are present with modifications, however (Fig. 14). The cortical area is composed of cells more elongated than those in the frond and is a larger number of cells deep. Internally these pass into the large cells of the intermediate area (Fig. 19). Here there is a noticeable difference from the condition in the frond. A large number of the elongated central cells find their way into this area and a cross section of the stipe shows them in cross, oblique and even longitudinal section between the large starch-containing cells of the intermediate area which stand out very clearly in large radial filaments (Fig. 21). The central area in the stipe is a very compact area and is made up of a large number of thin filaments interwoven in a very complicated manner (Figs. 20, 21). These cells correspond to those of the elongated filament bundles in the frond. There are in the stipe, moreover, a small number of larger cells also elongated and corresponding to the cells of similar shape and position in the frond. In cross section the cut-off ends predominate (Fig. 20), while in longitudinal section the cut-off ends are few; the longitudinal view of the filaments is the predominant one and the intricate weaving (Fig. 21) is very plainly seen. A longitudinal section through the annulate portion shows the absence of the cortical and intermediate layers in the region of the annulus indicating the continuity of these areas in the frond and stipe (Fig. 15).

A longitudinal section through the growing point shows but two areas in the growing region. There is no distinct intermediate area although a number of large cells may be present (Fig. 16). The two areas are the cortical in which the filaments are all parallel, perpendicular to the stipe surface and pseudc-parenchymatous in character, and the central, which is as before a mass of densely woven elongated filaments. The end of the intermediate area of the frond can readily be seen in such a section (Fig. 16).

Holdfast.—The holdfast, *i. e.*, the expanded portion of the stipe at its base, presents a similar anatomical structure to that of the stipe with the exception of one modification. The lower cortical and intermediate areas which are in contact with the surface to which the plant is moored are changed into a yellowish brown disorganized mass which probably serves as a cementing substance in attaching the plant to the rocks. Indications of the former cell structure can be seen in occasional cavities and in the arrangement of these cavities. The area adjoining the cement layer is composed largely of elongated filaments (Fig. 24).

Protoplasmic Connections.—In freshly cut material the protoplasmic connections between cells, is very plainly to be seen in many of the starch cells of the intermediate area. They are also easily seen in the larger cells of the central area, as well as in the small cells of the same area. The cortical area of the stipe furnishes particularly good views of this continuity (Figs. 13, 18).

Reproductive Tract (Figs. 11, 12).—I have been unable to find, in the material at hand, and it is considerable in amount, any trace of cystocarp development. The following description of the occurrence and structure of the cystocarp of the genus is translated from Schmitz and Hauptfleisch,* the former of whom has made a personal study of the cystocarp of *C. rosa-marina* (Schmitz, l. c.): The carpogonial branches and auxiliary cell branches are distributed in the fertile portions of the frond in large numbers in the loosened inner portion of the inner cortex of the upper side of the leaf, together with numerous vermiform sterile cellular threads. Cystocarps distributed in large numbers on the fertile fronds, comprising a broad zone along the edge of the frond on its upper surface, imbedded in the much loosened inner cortex of the upper surface of the frond, swelling out into an arch the superposed outer cortex which is punctured by pores. The nucleus of the form of a mulberry and pierced by single strands of sterile tissue. Gonimolobes separated only at first, later confluent.

Kützing † states that the "gongyli rotundi" described by Postels and Ruprecht as two kinds of fruiting bodies in *Constantinea rosa-marina* are ordinary cells of the cubcortical layer.

* Schmitz and Hauptfleisch. In Engl. and Prantl. Nat. Pflanz. I. Teil. Abth. 2. 520, 521. 1897.

† Phyc. Gen. 400. 1843.

Tetraspores are known only in *C. sitchensis*. They are oblong and zonate, lodged in nemathecia. The nemathecia are found exclusively on the lower surface of the frond more abundant near the outer half. They are in the form of delicate, slightly-raised "wart-like," often confluent bodies of a whitish color. They average 3.5–4 mm. in diameter and often become so numerous that they completely cover a very large part of the lower surface of the frond. The nemathecia are covered by the gelatinous layer on the surface of the paraphyses. The paraphyses are elongated, narrow, peripheral cells (Figs. 11, 12). The tetraspores arise as club-shaped elongations of peripheral cells between the paraphyses and are divided zonately into four chambers. The tetraspores are numerous in each nemathecium. Their average size is 108 x 22 mic.

Endophyte.—In a large majority of sections and upon all material examined, are present peculiar green approximately spherical bodies imbedded in the cortical tissue of the frond. They are endophytic algæ and probably the *Chlorochytrium inclusum* of Kjellman. In general they are pear-shaped with their small end toward the surface and the cell wall at that end thickened. They are greenish in color and contain a number of conspicuous pyrenoids, the central areas of which stain very readily, having a particular affinity for aniline blue. The protoplasm is denser toward the small end where the cell wall is also thick. It is with this end that the endophyte breaks through the cortical tissues of the nurse plant. I have as yet been unable to detect any zoöspore formation. This interesting little endophyte will receive a more complete discussion in a subsequent paper.

Conclusions.—The material upon which these observations are based was distributed by Miss Tilden as *Constantinea sitchensis* Post. and Ruprecht. A careful comparison of it with the plates and descriptions of Postels and Ruprecht shows however that the plant under observation might as well perhaps be placed under *Constantinea rosa-marina*. The material agrees in almost every particular with *C. rosa-marina* having, however, single terminal fronds and an occasional evident dichotomy of branching. The differences enumerated above in the descriptions of the two species can hardly be considered of specific importance. The length of the internodes may vary considerably. The greater part of the material under observation contained long internodes. This material was collected in late summer. The number of fronds on a branch is also given specific value by Postels and Ruprecht. It is probably of important significance that *no* tetraspores were found by these authors upon *C. rosa-marina* but that large numbers were found upon *C. sitchensis.* Figure 6 represents a young frond having no tetraspores but with a succession of fronds similar to those of *C. rosa-marina*, while almost all of the remaining material had solitary terminal fronds crowded with tetraspores. The material collected in May, 1897, contains tetraspores.

The dichotomy of the branching of *C. sitchensis* is a comparatively late development in the growth of the stipe and is not seen in the older parts. *C. sitchensis* is further described as larger in all parts than *C. rosa-marina*, though actual measurements given do not accord with this. *These facts suggest the probability that the C. sitchensis of Postels and Ruprecht is the late summer stage of C. rosa-marina.* This supposition explains satisfactorily the absence of tetraspores in the one and of dichotomy of the stipe in the other, the comparative lengths of "internodes" and the difference in sizes of the two plants.

The observations and impressions of subsequent writers add additional weight to this view. In recounting the founding of the genus by Postels and Ruprecht upon the *Fucus rosa-marina* of Gmelin, Agardh (l. c. 1851) observes of *C. sitchensis* "novo consimili adjecta specie" (p. 294) and of *C. rosa-marina* "præcedente (sitchensis) videtur proxima, cum nulla alia confundenda" (p. 296).

Of the material collected by David Lyall at Vancouver island "adrift on the beach at Victoria harbor" and reported as *C. sitchensis*, although corresponding in size to *C. sitchensis* Harvey (l. c. 1862) remarks "perhaps this is only a luxuriant state of *C. rosa-marina*."

From these facts it would seem, therefore, highly probable that *C. sitchensis* and *C. rosa-marina* are but different forms of the same plant, and since the work of Schmitz has removed *C. reniformis* to the genus *Neurocaulon* where also it is probable that *C. thiebauti* should be classified, that *Constantinea* is a monotypic genus, with *Constantinea rosa-marina* as the only species.

Description of Plates.

Fig. 1. Young plant with group of young branches on the holdfast. x ½.

Fig. 2. Portion of the plant showing the entire edge and form of young fronds (from dried material). x ½.

Fig. 3. An old frond showing lacerated border and perforations (from dried material). x ¼.

Fig. 4. A frond showing striations on the lower surface (dried specimen). x ½.

Fig. 5. Plant with fronds almost entirely cut away showing the growing points, the annulations of the stipe and the dichotomous branching. *a.* annulations. *g.p.* growing point. *f.* frond cut off. x ½.

Fig. 6. Small branch showing a rapid succession of laminæ. x ½.

Fig. 7. Diagram of a tangential cross section of the frond. *c.* cortical area. *int.* intermediate. *e.* bundles of enlarged filaments. *l.* loosely woven cells of central area.

Fig. 8. Cross section of a frond showing bundle of elongated cells in central area in transverse section. Letters as above. Drawn with camera lucida. x 250.

Fig. 9. Cross section of a frond showing a longitudinal section of a part of a bundle of elongated central cells. Drawn with camera lucida. x 250.

Fig. 10. Cross section of a frond stained for a minute in a strong solution of I in KI. *ch.* chromatophores. *st.* starch grains. Drawn with camera lucida. x 345.

Fig. 11. Cross section of a frond through a nemathecium. *cent.* central layer. *p.* paraphyses. *t.* tetraspores. Cells are drawn only in outline. Contents have been omitted. Camera lucida. x 83.

Fig. 12. Cross section of a frond through a nemathecium showing tetraspores. Drawn from a glycerine mount in which the gelatinous walls became almost entirely obliterated. The walls are, therefore, omitted except around the tetraspores. x 250.

Fig. 13. Cells from central area showing protoplasmic connections. Camera lucida. x 250.

Fig. 14. Diagram of cross section of stipe in internode. Letters as in frond.

Fig. 15. Diagram of longitudinal section of a stipe through a node.

Fig. 16. Diagram of a longitudinal section of the stipe through a growing point.

Fig. 17. Peripheral cells from cross section of stipe showing the striations in the outer gelatinous covering. x 345.

Fig. 18. Filament from a cross section of the stipe in the cortical

area showing the dichotomy of the branching. Camera lucida for an outline. x 250.

Fig. 19. Cross section of stipe including the cortical and the beginning of intermediate layer. The cut off ends of elongated central filaments are seen in the intermediate area. Camera lucida. x 130.

Fig. 20. Cross section of stipe in the central area; shows the predominance of elongated filaments. x 250. Outlined with camera lucida.

Fig. 21. Longitudinal section of a stipe at the inner edge of the cortex; shows the complication of the elongated filaments. Outlined with camera lucida. x 250.

Fig. 22. External view of holdfast seen from below. x ½.

Fig. 23. Diagram of cross section of a holdfast. *m.* layer of disorganized mass on lower surface by which the holdfast adheres.

Fig. 24. Lower portion of the cross section of the holdfast showing the attaching layer *m.* Camera lucida. x 250.

Fig. 25. Diagram of a cross section of a frond showing the distribution of an endophytic alga (probably *Chlorochytrium*). Larger number on the upper surface. *end.* endophyte.

Figs. 26 and 27. Cross section of a frond; detail drawing of endophyte. *w.* endophyte wall. *pd.* pyrenoid. *n.* cell of nurse plant in outline. Camera lucida. x 250.

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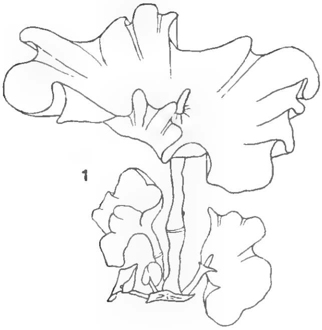

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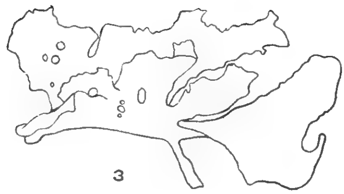

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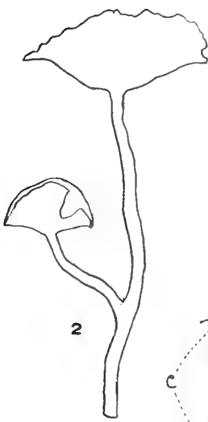

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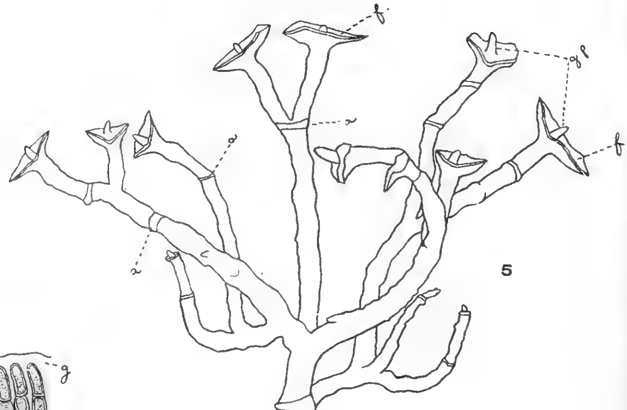

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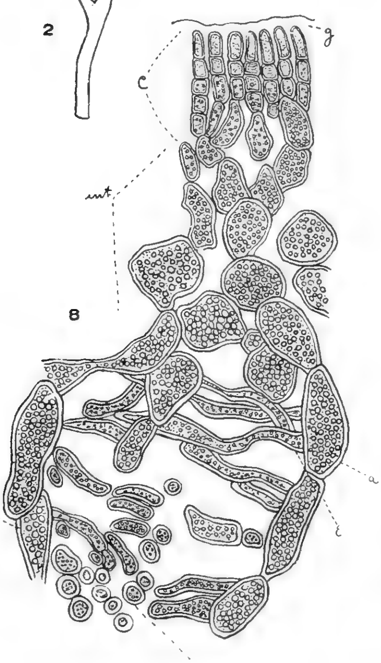

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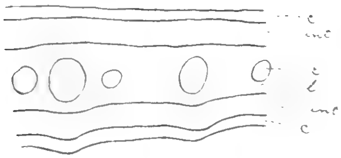

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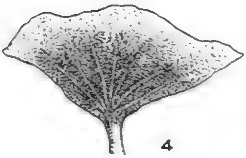

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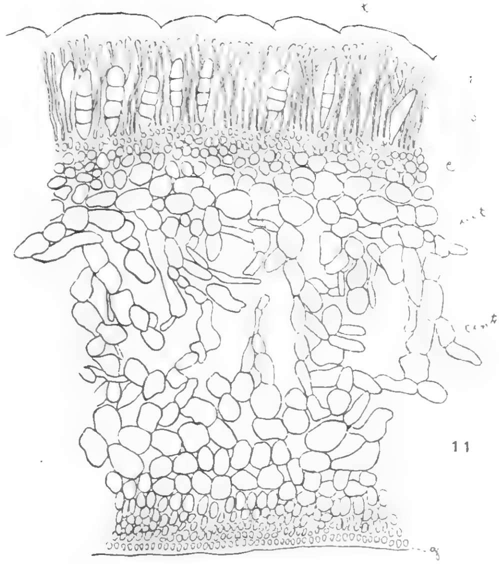

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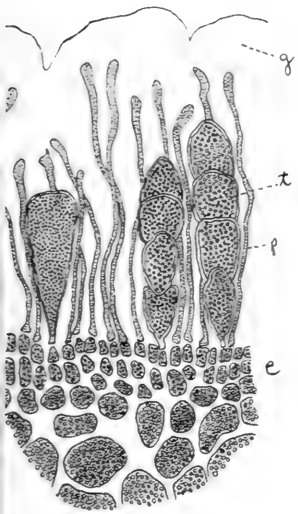

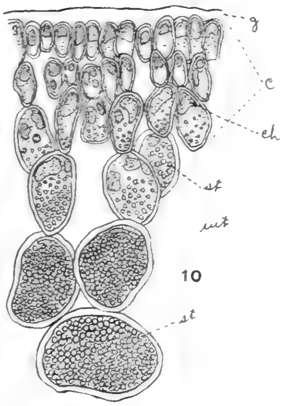

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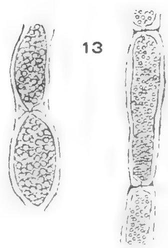

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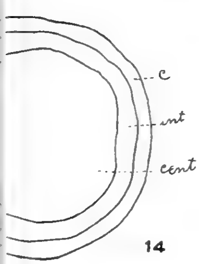

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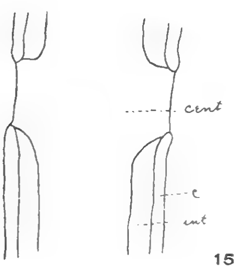

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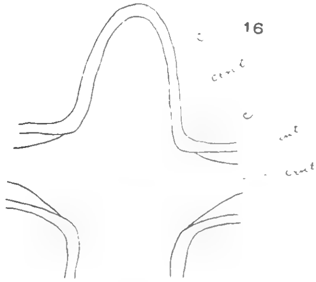

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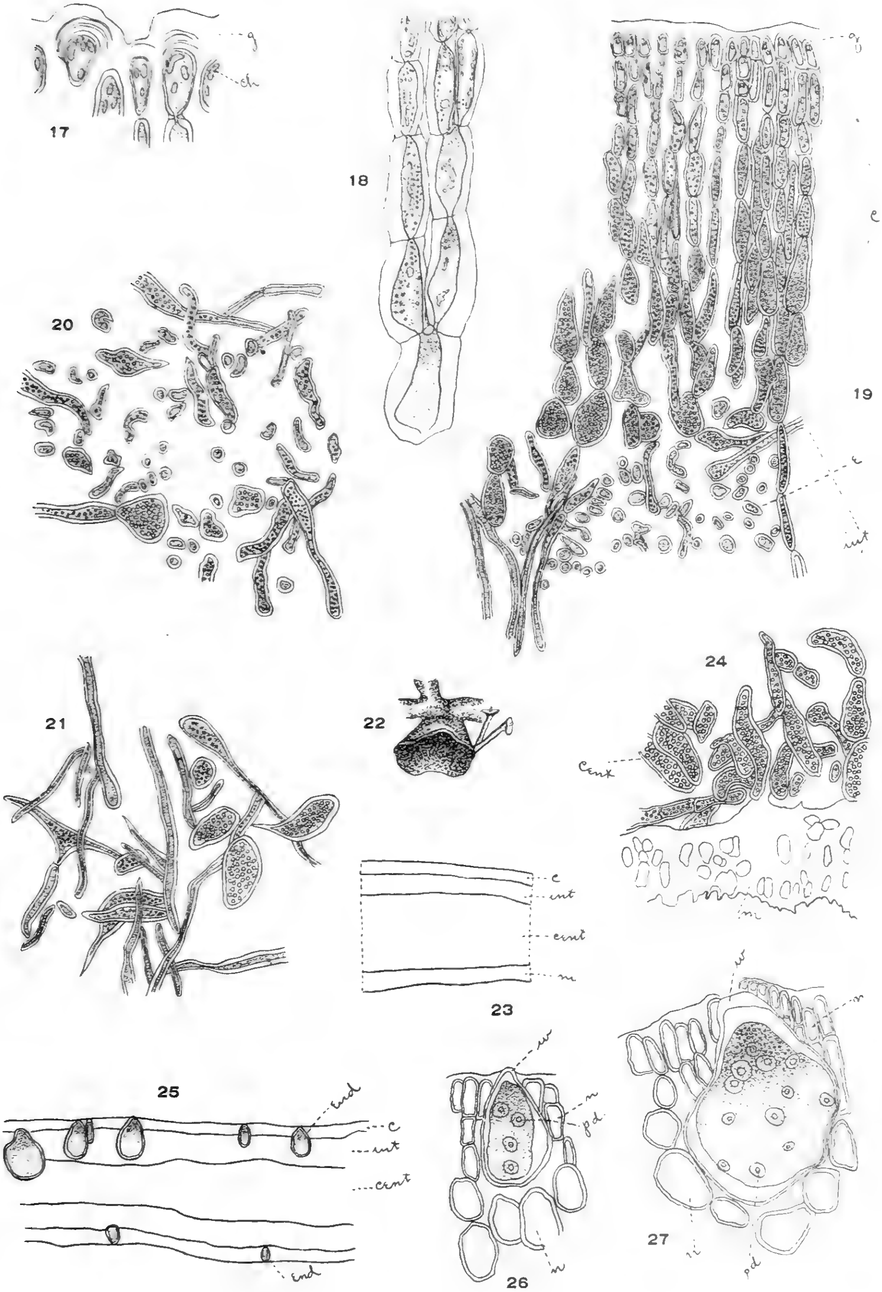

PLATE XVIII

HELIOTYPE PRINTING CO. BOSTON

XIV. EXTENSION OF PLANT RANGES IN THE UPPER MINNESOTA VALLEY.

L. R. Moyer.

The following notes refer to plants that have been collected in the upper Minnesota valley since the publication of Professor MacMillan's *Metaspermæ of the Minnesota Valley*. Duplicates have been deposited in the Herbarium at the State University.

Thlaspi arvense L.

This old world crucifer has become well established in the railroad yards at Montevideo and is spreading rapidly.

Conringia orientalis (L.) Dumort.

This plant, first collected in wheat fields in Chippewa County in 1894, is spreading very rapidly and seems likely to become one of the worst "mustards" with which the farmer has to contend.

Sisymbrium altissimum L.

This plant, too, is spreading very rapidly along the railroad tracks at Montevideo, and seems likely to become a very troublesome weed.

Peucedanum nudicaule (Pursh) Nutt.

This plant is found to be quite plentiful in the upper Minnesota valley on thin gravelly land near ledges of igneous rock. It is one of the earliest spring flowers.

Potentilla hippiana Lehm.

This western *Potentilla* is occasionally found on ledges of gneiss rock near Montevideo.

Helianthus annuus L.

Among the recent arrivals at Montevideo, an immigrant from the West, is the annual sunflower. It is traveling along the railroads.

Grindelia squarrosa (Pursh) Dunal.

This is another western plant that seems to be traveling east. It has but recently become well established in the railroad yards at Montevideo.

Lactuca scariola L.

Another Old World weed that has but recently arrived at Montevideo is this species. It is spreading with great rapidity.

Senecio vulgaris L.

Recently arrived at Montevideo, this plant is becoming common as a weed in gardens and waste grounds.

Poa pseudopratensis Scrib. & Ryd.

A *Poa* collected at Clara City, in Chippewa County, has been identified by Professor Lamson-Scribner as this species.

Fraxinus lanceolata Borck.

A study of this species based on a large collection of material from the prairie portion of the State, some of which was sent east for comparison, makes it probable that all of our ash trees are referable to this species. *F. Americana* appears to be absent from western Minnesota.

Cactus viviparus Nutt.

This cactus is found quite abundantly on granite ledges in the ancient valley of the "Warren," about two miles southeast of Ortonville. Its bright red flowers are strikingly beautiful.

Astragalus flexuosus (Hook.) Doug.

This species is quite plentiful near the railroad yards at Ortonville.

XV. LIST OF HEPATICÆ COLLECTED ALONG THE INTERNATIONAL BOUNDARY BY J. M. HOLZINGER, 1897.

ALEXANDER W. EVANS.

1. **Aplozia autumnalis** (DC.) HEEG. F, N.
2. **Bazzania trilobata** (L.) S. F. GRAY. F, R, U.
3. **Blepharostoma trichophyllum** (L.) DUMORT. R.
4. **Cephalozia catenulata** (HÜBEN.) SPRUCE. F.
5. **C. media** LINDB. P.
6. **Frullania Eboracensis** GOTTSCHE. F.
7. **Jungermannia barbata** SCHREB. F, G, P.
8. **J. quinquedentata** WEB. P, R.
9. **J. ventricosa** DICKS. S.
10. **Lejeunea serpyllifolia** (DICKS.) LIB. U.
11. **Lepidozia reptans** (L.) DUMORT. P, R, S, U.
12. **Plagiochila asplenioides** (L.) DUMORT. N, P, U.
13. **Porella platyphylla** (L.) LINDB. F, U.
14. **Ptilidium ciliare** (L.) NEES. C, F, S, U.
15. **Radula complanata** (L.) DUMORT. C, F, U.
16. **Scapania glaucocephala** (TAYL.) AUST. F.

C = Camp IV., on the Prairie Portage, shore of Basswood Lake, near the rapids from Sucker Lake.

F = Fall Lake, near the foot of Kawasatchong Falls, seven miles north of Ely.

G = between Gunflint Lake and Grand Portage.

N = stream flowing from North Lake into Little Gunflint Lake.

P = Grand Portage Island.

R = Pipestone Rapids, on Basswood Lake.

S = Safety Island.

U = United States Peninsula.

XVI. OBSERVATIONS ON CHLOROCHYTRIUM.

E. M. Freeman.

In 1850 Mettenius found numerous green cells in the thallus of *Polyides lumbricalis* which resembled closely what are now classified as the Endosphæreæ of the Protococcaceæ. He interpreted them as spore-mother cells of the red seaweed upon which they were found. Thuret fourteen years later observed these same structures and interpreted them as parasitic zoöspores which on germination produce the bushy thallus of *Cladophora lanosa*. Cohn in 1865 was able to confirm the observations of Mettenius and of Thuret, except as to the germination of the endophyte into *Cladophora lanosa*.

The condition of endophytism was considered at that time as indicative of parasitism. Hence new interest was aroused in the investigation of these lower forms when Rees and Schwendener at about the same time (1871) advanced independently the theory that the *Collema* type of lichen is to be derived from a discomycetous fungus, the mycelium of which has penetrated the mucilage of a *Nostoc* completely surrounding the latter. Reinke's observations on *Nostoc* in the stems of *Gunnera scabra* and the work of Milde and Janczewski on *Nostocs* in liverworts demonstrated the occurrence of *Protococcus*-like algal forms in the plant tissues of higher plants. Cohn in 1872 suggested that the presence of the Nostoc filaments in *Gunnera* and *Anthoceros* is perhaps to be explained as an accidental entry of the movable *Nostoc* filaments into the tissues of the nurse plant, their continued growth in this new sheltered position and their subsequent imprisonment by the growth of the surrounding tissues of the nurse plant. In contrast to this form of endophytism Cohn describes the new genus *Chlorochytrium*, which he considers to be a true parasite in certain species of *Lemna*. The zoöspores, very numerous on the surface of the host, send out a germination tube between two epidermal cells. The membrane of this tube becomes thickened by subsequent layers, the tube swells with the absorption of the chlorophyll and protoplasm and the intercellular endophyte results, with a cellulose button protruding from the point where the germinating tube entered. The endophyte then becomes pyriform and almost opaque on account of the density of the chlorophyll. By free cell formation large cells are formed in the endophyte and these finally break into a large number of zoöspores which are expelled through the cellulose protuberance from the nurse-plant epidermis. The endophyte is, therefore, an independent organism closely related to *Hydrocytium* (*Characium* A. Br.) on the one hand and to *Synchytrium* on the other. With the Eu-Synchytrium group its cell form and the formation of zoöspores by a preliminary division into segments, corresponding to the zoösporangia of *Synchytrium*, agree, but it differs in the presence of chlorophyll and of a germination tube and in its intercellular position. Upon these observations Cohn founded the genus *Chlorochytrium* and described it as follows:

Planta endophytica viridis unicellaris, globosa ovoidea vel irregulariter curvata bi, tri, multiloba dense conferta plasmate viridi, primum in segmenta majora diviso dein secedente in zoosporas immersas pyriformes virides processibus tubulosis extus emissas.

Chlorochytrium lemnæ upon which the genus is based is then described.

Cohn pronounces *Chlorochytrium* a true parasite. That no deleterious effects upon the host are visible is paralleled in *Peronospora* and *Synchytrium*. In its intercellular position it resembles the Uredineæ.

Two years after Cohn's observations were published Kny described a new species of *Chlorochytrium* endophytic upon *Ceratophyllum demersum*. It differs from *Chlorochytrium lemnæ* in size and in the absence of a cellulose button.

In 1877 Wright established a third species of *Chlorochytrium*, *C. cohnii* Wright.

"The zoöspores impinging on the fronds of several species of marine algæ quickly assuming a figure-of-eight form, the lower sphere growing into the frond and rapidly assuming comparatively large dimensions, the upper sphere remaining as a tube-like neck portion to the larger mass. On the cell arriving at an adult stage, the whole of the green protoplasmic contents divides into a number of from 10–30 nearly circular zoöspores, which escape through the neck-shaped portion.

"Living in the thallus of various species of *Schizonema*, *Polysiphonia*, etc.; also on the Infusoria found at Howth."

Wright states further that there are two kinds of zoöspores, large and small, the latter being the more numerous.

Szymanski in 1878 described *C. knyanum* apparently identical with the plant mentioned by Kny four years before as inhabiting the tissues of *Ceratophyllum demersum*. This species was found on *Lemna minor* and possessed a cellulose button which did not protrude farther than twice the thickness of its outer wall above the epidermis of its nurse plant.

Klebs published the results of his investigations on *C. lemnæ* in 1881. *Chlorochytrium* in the younger vegetative stages contains a light green chlorophyll-bearing protoplasm with isolated starch grains surrounded by a cell sap vacuole (see below, pyrenoids). In the later stages the grains increase in number, the mesh-work of green bands becomes smaller, the chlorophyll darker until almost opaque and the protoplasm finally becomes coarsely granular. After a resting period of a week or more the zoöspores are formed by successive bipartitions of the cell contents, at first by perpendicular, later by radially disposed walls.

The number of divisions is not known. Liberation of the zoöspores is accomplished by absorption of water resulting in the splitting of the *Chlorochytrium* wall and of the superposed *Lemna* tissues.

The conjugation of the biciliate zoögametes into larger quadriciliate zoözygotes was observed, a fact which may throw light on the macro- and microzoöspores of Wright's species. Klebs observes that Cohn's account of the liberation of the zoöspores is without observational foundation and doubts its accuracy. He also calls in question the appropriateness of placing Wright's species in the genus *Chlorochytrium* and further suggests the probability that *C. knyanum* is but the asexual form of *C. lemnæ* since no copulation had been observed between the zoöspores. *C. pallidum* Klebs and many similar forms are probably mere "place varieties" of *C. knyanum*.

Klebs points out with much truth that no proof has been given of the much averred parasitism of *Chlorochytrium* by Cohn and other previous investigators. On the other hand *Chlorochytrium* has well developed chlorophyll and lives near the surface where abundant light is available. The requisite inorganic matter may gain access to the cells by the constant or at least periodical submersion in water.

Chlorochytrium lemnæ penetrates dead as well as living leaves and culture methods demonstrate an entire lack of dependence of the endophyte upon a host plant. In many endophytes zoöspores can be developed on culture slides for months. No proof has as yet been adduced for any injury of the host beyond the results of the mechanical pressure exerted. The explanation then of endophytism is to be found not in parasitism but in the mechanical protection of position, which the intercellular spaces of the host offered; hence the appropriateness of the term "Raum Parasiten." It is, of course, possible for parasitism to develop from such a condition and this development seems to be in evident progress in such a nearly related form as *Phyllobium dimorphum* and also perhaps in *Nostoc lichenoides*. In the systematic relations of *Chlorochytrium* and the nearly related genera, Klebs briefly points out the intermediate position of *Chlorochytrium* and *Endosphæra*, between the Protococcaceæ and the Chytrideæ, the isolated position of *Scotinosphæra* and the probable affinities of *Phyllobium* on the one hand with *Chlorochytrium* and on the other with *Botrydium*.

Schaärschmidt, 1881, found zoöspores of *Chlorochytrium* in a Desmid culture in which the zoöspores subsequently developed, confirming Kleb's view on the parasitism of the endophyte. In 1883 Kjellman described the following species:

Chlorochytrium inclusum Kjellman.—"In the vegetative stage spherical or subspherical, entirely included within the nurse plant, with the formation of the zoöspores becoming slightly elongated, short-conical, flask-shaped, ovoid or ellipsoidal, finally bare at the pointed apex, which penetrates the cortical layer of the nurse plant and emitting the zoöspores through an ostiole which has been formed." This species is endophytic upon *Sarcophyllis arctica*, mostly near the surface but sometimes in the middle of the host. It averages 80–100 mic., has yellowish-green contents and a cell-wall which is thin and of equal thickness. The chromatophore is thin and is spread along the wall. With the elongation at the formation of zoöspores the membrane thickens towards the outer surface especially, and a cone-shaped growth of cellulose is formed. The protoplasm then takes on a more intense yellow green and divides into numerous zoöspores. Numerous bulgings of the plant cell are produced probably by the growth of the surrounding tissues of the host. An ostiole is formed at the apex of the cellulose out-growth by which the zoöspores escape. Those cells found in the center of the host may attain as great a diameter as 275 mic. The even thickness of the wall of these cells suggests that they may be resting stages. Kjellman refers this plant to the genus *Chlorochytrium*, but hesitatingly on account of his lack of knowledge about the further development. He found *C. inclusum* in all of the *Sarcophyllis edulis* material which he has examined. Zoöspores are most abundantly produced in winter, but are also found in summer. The endophyte occurs in greatest abundance and most strongly developed in *Sarcophyllis arctica.* Its range is apparently coextensive with that of *Sarcophyllis arctica; i. e.*, throughout the arctic region, except in the North Atlantic, most abundant in the eastern part of the Siberian sea.

Three more new species were described by Schroeter in 1883. *Chlorochytrium rubrum* with red contents and occupying the air spaces of the leaves and stems of *Peplis portula* and of *Mentha aquatica; Chlorochytrium viride*, in the leaves of *Rumex obtusifolius;* and *C. lætum*, a spherical cell with yellow contents which become green in water, found in *Lychnis flos-cuculi.*

The investigations of Moore on *Chlorochytrium lemnæ* published in the following year brought to light no new facts of importance. Moore held that the nearest affinities of *Chlorochytrium* lie with *Protomyces.*

In 1887 Hieronymus described *C. archerianum* in punctured cells of *Sphagnum* leaves, and characterized by a greatly developed cellulose button. Zoöspores are formed regularly but do not copulate. P. Hariot, 1889, collected *C. inclusum* on species of *Gigartina* at Cape Horn, supposedly identical with Kjellman's *C. inclusum.*

In his Conspectus of Endophytic Algæ, Mobius, 1891, mentions in addition to those species enumerated above, *C. dermatocolax* which was described by Reinke and found on species of *Polysiphonia* and *Sphacelaria*, and in his opinion should be classified under the genus *Chlorocystis*, since it is marine, is intracellular and emits zoöspores singly.

C. schmitzii was described (1893) by Rosenvinge from Greenland material on *Cruoria arctica*. The cell is without a cellulose button or papilla, is more or less attenuate at the base and has a single chromatophore with sometimes two pyrenoids. Zoöspores were not observed.

Collections, Methods, etc.—Upon the *Constantinea* material which was collected by Miss J. E. Tilden at different points along Puget sound and was distributed as *Constantinea sitchensis* Post. and Rupr., were found a large number of endophytic unicellular, chlorophyllaceous algæ, referred to the genus *Chlorochytrium* of Cohn. The endophyte was found in abundance on all of the *Constantinea* collected. One collection was made in August, 1897, near Seattle, and in the summer of 1898 (May 25–July 2), five were made at as many points farther up the Sound. Most of the material used in the following investigations was fixed and preserved in a 2 per cent. sea-water solution of formalin. The green color of the endophyte was well preserved. The lower ends of the cells have in very many cases an irregular outline which may possibly be in part due to shrinkage but is caused for the most part by pressure of the surrounding *Constantinea* cells. In all of this endophyte formalin material and in the dried material as well, though not so markedly, brown bodies were found jutting out between the chromatophore and the cell wall and assuming various forms (see below). These bodies were undoubtedly due to a chlorophyllan reaction, the hypochlorin reaction of Pringsheim. The formalin solution when tested was found to give a slightly acid reaction.

Sections of *Constantinea* cut freehand between elder pith furnished most of the material for study. They were mounted either in the two per cent. formalin sea-water solution, in glycerine, or in glycerine jelly. Material carried through the usual paraffin method stained and mounted in Canada balsam has also furnished useful sections. The abundance of the endophyte makes it easy to get favorable surface and sectional views of it.

General Habit and Structure.—The endophytes on *Constantinea sitchensis* occur on both the upper and lower surfaces of the fronds. I have been unable to find any on the stipe. They are most abundant on the older fronds and especially towards the peripheral portion. From some young fronds they are almost altogether wanting. They occur in greatest numbers on the lower surface while rather few are found on the upper side. The following figures are taken from a medium-sized frond in the peripheral region: on the under side 140–160 (sometimes as many as 230) in one square mm.; on the upper surface 60–65 in the same area. Many areas of 4 square mm. on the upper surface contained no endophytes.

The endophytic cells are found almost exclusively in the tissues just beneath the pseudoepidermis of the nurse plant, with the slightly pointed end just at or just below the surface. They occur in rare cases in the central part of the frond completely enclosed. The pointed end protrudes from the tissues of the nurse plant in but few cases and then not more than for a distance equal to one-half the thickness of its outer wall. The cells not infrequently occur between the paraphyses of the nemathecia of *Constantinea* where they usually penetrate to but not into the tissues beneath.

The predominant form assumed by the endophyte is pear-shaped with the smaller end directed toward the surface of the nurse plant. The cells are often ovoidal and even ellipsoidal. In the central portion they assume a spheroidal form. In the paraphyses they become elongated or assume a figure-of-eight form similar to that described by Wright for *Chlorochytrium cohnii.* The inner ends of the cells are marked more or less by the bulgings undoubtedly caused by the pressure of the adjacent cells of the nurse plant.

The cells average 85–115 mic. in length and 40–85 mic. in breadth but often attain 143 x 100 mic. The wall in some cases is 28 mic. thick at the outer surface and 8 mic. thick around the remainder of the cell, but usually is less than one-half of these dimensions. The lamellation of the cell wall can clearly be seen in many sections (especially glycerine mounts) and is due probably to the apposition of successive layers of cellulose. Chlorophyll occurs in the form of a single yellowish-green plate in which are included a large number of fine refringent granules. This chromatophore extends around the entire wall of the cell and contains a varying number of very conspicuous pyrenoids, which are flattened spherical in form, 5–11 mic. in diameter, and jut out into the cavity of the cell. As many as thirty-nine have been found in a single cell and at least one pyrenoid can be seen soon after the cell begins to penetrate the tissues of the nurse plant. The pyrenoids show a clear central portion probably proteid. In sections stained heavily with aniline blue the central portion appears blue. Around the clear center are arranged 5–10 plates of starch which stain brown with both a KI and an alcohol solution of iodine. By careful washing of material stained in an alcoholic solution of iodine and with the aid of a $\frac{1}{16}$ oil immersion lens a distinct violet tinge is discernible in the plates. The protoplasmic contents of the cell are usually most dense in the pointed part. Between the chromatophore and the cell wall are found numerous rust-brown to black (in a few cases copper-colored) bodies of different form and size. In some places they occur in diffuse patches the limits of which are often indefinable, in others as five-pointed rosettes. Again they may appear filiform, partially and usually irregularly coiled or forming a delicate and loose network. I have interpreted these bodies as products of the action of the dilutely acid formalin solution and as identical with the hypochlorin of Pringsheim. His plates agree closely with much of the material at hand. In accordance with Pringsheim's account of the chemical reactions of hypochlorin, these brown bodies are wanting in those sections which have been carried through the alcohols in the method for paraffin embedding.

A large amount of material has been examined but in no case has even a trace of the production of zoöspores or gametes been found. The stages in the penetration of the nurse plant, consisting in the elongation of the at first spheroidal cell, the subsequent withdrawal of the protoplasm into the inner end and the increase in size of the latter to form the mature pyriform cell, have been observed, but nothing to indicate the formation of zoöspores.

Conclusions.—It is therefore upon the basis of vegetative characters that the endophyte described above is provisionally placed in the genus *Chlorochytrium* under *C. inclusum* Kjellman. Upon examination of the *Chlorochytrium inclusum* found upon *Dilsea* (*Sarcophyllis*) distributed in *Phycotheca Boreali-Americana* (Fasc. XI., no. 514) this is seen to possess a thicker cell wall than the material on *Constantinea sitchensis*, is almost spheroidal, larger, has denser dark green contents, contains no pyrenoids (or very inconspicuous, if present at all) and resembles a resting stage. The time of collection, December, moreover, strengthens this last supposition. The material under observation was collected, on the other hand, in summer, May to July. The light yellow-green color, the absence of reproductive bodies and the abundance of small cells point strongly, I think, to the conclusion that this endophyte is but a young stage of *Chlorochytrium inclusum* Kjellman. A similar difference in the vegetative and resting stages of *C. lemnæ* are recorded in Klebs' observations (*pl. 39, f. 2 and 9*). The form and habit of the endophyte upon *Constantinea* accord best with Kjellman's description of *C. inclusum*; no mention, however, is made by Kjellman of pyrenoids, which are so conspicuous in the *Constantinea* material. It is suggested by De-Toni and also by Miss Whitting that Kjellman's species may possibly belong to *Chlorocystis*, a genus established by Reinhard in 1885. *Chlorocystis* is described with but one pyrenoid while the endophyte on *Constantinea* contains many. *C. schmitzii*, described by Rosenvinge, is but imperfectly known. I have seen in the sections studied a number of cases where the endophyte in *Constantinea* has assumed approximately the same irregular or obovoidal form shown in the figures of Rosenvinge. The only remaining marine species of *Chlorochytrium*, *C. dermatocolax*, lives in the outer membrane of *Polysiphonia* and, according to Möbius, belongs probably to *Chlorocystis*.

The great similarity in vegetative structure to that described by Kjellman for *C. inclusum* would indicate that the *Constantinea* endophyte described above is a midsummer stage of *C. inclusum* and I would provisionally place it in that species awaiting further information on the life history and development.

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Description of Plate XIX.

1. Diagram of a cross section of a frond of *Constantinea sitchensis* showing the endophytic *Chlorochytrium* cells on the upper (less numerous) and lower surface. *e.* endophyte. *p.* pseudoepidermis. *i.* intermediate area. *c.* central area of the frond.

2. Surface view of the frond of *Constantinea* (lower surface) showing the pseudoepidermis (*p*) with cavities (*e*) through which the endophytes have penetrated. x 57.

3, 4, 5, 6. Stages in the penetration of the nurse plant. *s.* pyrenoid. x 288.

7. *Chlorochytrium* cell with a not infrequent form. Shows filamentous form of hypochlorin. x 288.

8. Cell showing elongated form of endophyte found amongst the paraphyses of the nurse plant. x 288.

9. Large *Chlorochytrium* cell of typical form. x 288.

10. Detail showing the position of a *Chlorochytrium* cell in the cross section of the *Constantinea* frond. Letters as in no. 1. x 288.

11. The outer end of a *Chlorochytrium* cell showing the lamellation of the cell wall. x 288.

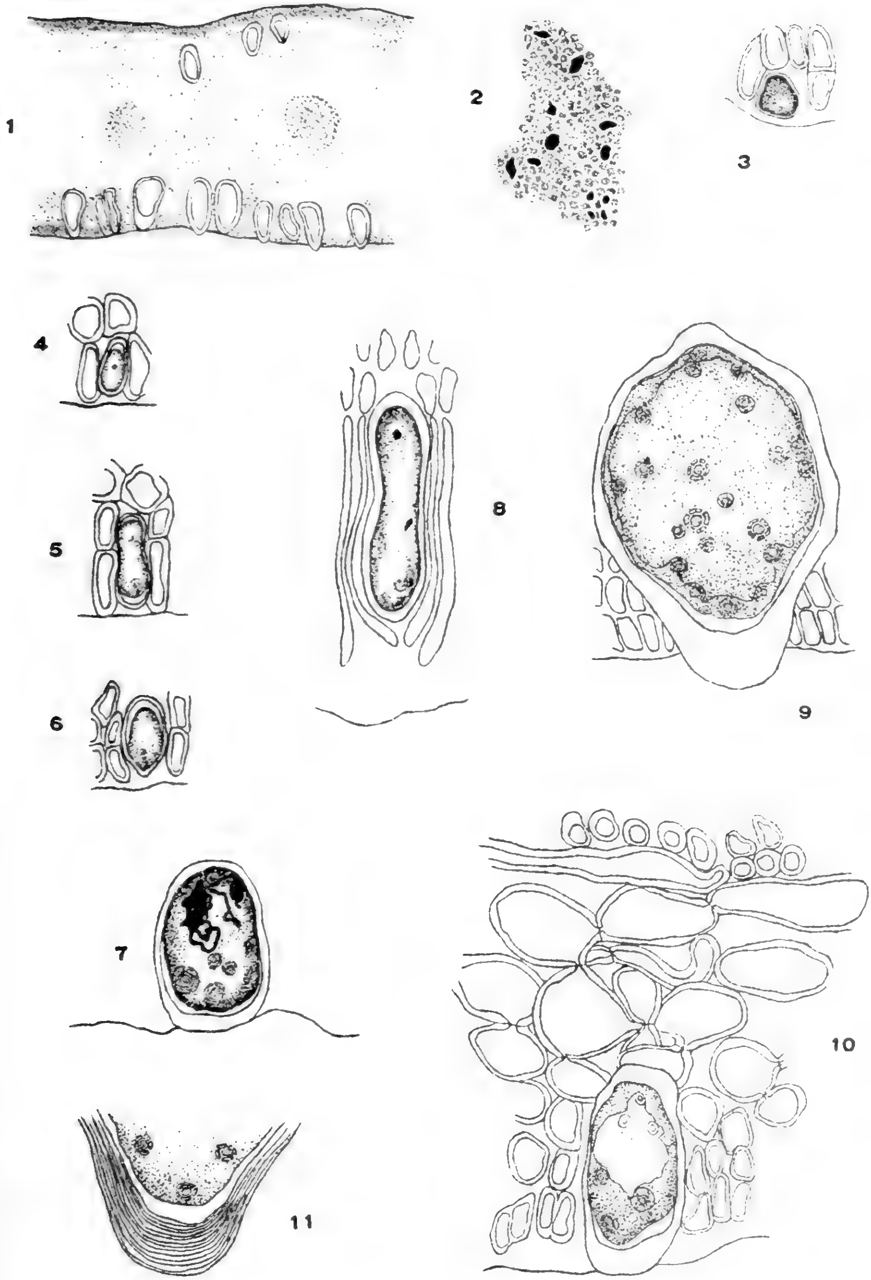

PLATE XIX.

THE HELIOTYPE PRINTING CO., BOSTON.

XVII. OBSERVATIONS ON RHODYMENIA.

FREDERIC K. BUTTERS.

History and Literature.—The genus *Rhodymenia* was founded by Greville in 1830. As originally constituted it contained species which have since been referred to *Gracilaria*, *Gigartina*, *Kallymenia*, *Calliblepharis* and other genera. Agardh (3), p. 376, states that in his Mediterranean Algæ (1) he transferred many species to the genera *Gracilaria*, *Gigantina* and *Kallymenia*, but united *Calliblepharis* with *Rhodymenia* under the latter name. In 1849 Kützing in his Species Algarum, p. 778, united the species of the genera *Rhodymenia* and *Gracilaria* together with some other species under the generic name *Sphærococcus*.

Agardh (2), p. 15, (3) p. 375, revised the genus *Rhodymenia* and gave it substantially its present limits and generic characters. The generic description as given by De-Toni and Levi, p. 19, is as follows: Frond plane, membranaceous, dichotomous or palmate, proliferate from the margin or surface, composed of two layers; interior cells oblong, cortical minute, rounded; cystocarps scattered throughout the frond, each within an hemispherical pericarp opening by a carpostome, composed of cells, the outer radiating the inner concentric; cystocarp with a simple rounded or somewhat lobed nucleus; nucleus naked within the pericarp, on a basal placenta with paniculate-branched placental filaments sustaining the lobes; young fertile lobes disposed radially composed of articulated filaments, older obconico-rotund, bearing numerous protospores; tetraspores often collected into sori, cruciately divided; antheridia produced in superficial sori composed of minute hyaline cells in a single vertical series.

Greville spelled the name of this genus *Rhodomenia*. Montagne, p. 44, in 1839, employed this spelling in a list of Brasilian cryptogams, but in a footnote states that, in conformity to its etymology it should be spelled *Rhodymenia*. J.

Agardh (3) adopted the latter spelling and it has since been in general use, although *Rhodomenia* and, according to Ardissone, *Rhodhymenia* and *Rodhymenia* also have been occasionally employed.

Rhodymenia pertusa was first described and figured by Postels and Ruprecht, p. 20, *pl. 36*, under the name *Porphyra pertusa*. Kützing, p. 693, describes it under this name. He introduces a question, however, in respect to its generic determination. J. G. Agardh (3), p. 376, points out that the species should be classed as a *Rhodymenia* and not as *Porphyra*. He describes it as *Rhodymenia pertusa* (Post. and Rupr.) and places it, together with *Rhodymenia palmata* (Linn. Sp. 2: 1630) and *Rhodymenia peruviana* (J. Ag. Mscr.) in the section *Palmatæ* characterized by "tetraspores occurring throughout the surface of the frond, scattered or collected into sori." In his Epicrisis (Agardh, J. G. (4), p. 379), he assigns it the same position.

Agardh (3) gives the habitat of *Rhodymenia pertusa* as "in the Arctic Ocean near Kamtschatka (Mus. Petropolitani!); and near Greenland (Wormskjöld!)." Kjellman reports it it from the northwest coast of Spitzbergen and the west coast of Greenland. It was first reported from the northwest coast of America by Harvey (1) who found it among the algae collected by Captain Wilkes' exploring expedition. Harvey gives its locality as the Straits of St. Juan de Fuca. He compared Wilkes' specimens with an authentic specimen furnished him by Dr. Ruprecht and found them identical in species, though Wilkes' specimens were considerably larger than Ruprechts's. Harvey, p. 171, also reports the species as collected by Dr. Lyall in 1859–61, his specimens being "cast ashore on Point Roberts, and on rocks at low water, Fuca Strait." Cystocarps were present on both sets of specimens mentioned by Harvey. In commenting on the specific name, Harvey (1) p. 148, states that to him the perforations of the thallus appear to be due to casualties.

In 1893 Carruthers, p. 80, examined one of the specimens mentioned by Harvey as collected by Dr. Lyall. He found that in that specimen the cystocarps occur all over the much perforated segments; the majority are very young and project but little from the surface of the thallus. The structure of the thallus is that typical of the genus. He says "The cystocarp projects on one side of the thallus and possesses a fairly thick fruit wall of five or six cells in thickness arranged irregularly inwards. At the bottom of the fruit cavity is to be found the placenta formed of numerous small cells closely packed together and lying on the medullary layer of large cells.

"From the placenta the gonimoblast of more or less irregular shape, is borne on an elongated style cell and spreads upward into the empty fruit cavity.

"This gonimoblast is composed of numerous pear-shaped lobes which lie close together. The spores of these lobes become ripe nearly at the same time.

"The ostiole is generally quite in the center of the projecting fruit wall, and is similar to the ostioles of the kindred species."

Collection and Preservation.—All the material at hand was collected by Miss Josephine E. Tilden at Port Orchard, Kitsap County, Washington, on August 2, 1897. The specimens were dredged in water 4–6 fathoms deep. A small portion of the material was killed and preserved in 80 per cent. alcohol. The larger part of the material was dried. By soaking, this dried material so far regained its original form that the anatomy could be well studied although the cell contents were largely disorganized. All the observations upon the stipe and the proliferations were made upon this dried material; observations upon other points were made mainly upon the alcoholic material.

Methods.—The dried material was soaked in water until it regained its natural consistency. Various methods were employed in cutting the tissues. Much of the material was cut upon the Osterhout freezing chamber. (Osterhout, W. J. V., p. 195.) The alcoholic material was first passed into water —preferably through about three intermediate grades of dilute alcohol. When the alcohol was completely removed the material was in some cases infiltrated with gelatine solution and then mounted in a drop of gum arabic solution upon the freezing chamber; in other cases it was embedded directly in the gum arabic. On account of the firm nature of most of the tissues, this method of mounting directly in gum arabic proved quite as successful as that in which the tissues were first infiltrated with gelatine.

The sections, as soon as they were removed from the knife, were passed into 20 per cent. glycerine. Those which were to be stained were transferred from this glycerine to the staining solution, thence, after washing, back to the glycerine solution. The glycerine solution was allowed to concentrate by evaporation, and the sections were thence mounted into glycerine jelly. Portions of the frond were also embedded in pith and cut free-hand with the razor.

Some of the material was embedded in paraffine, according to the usual methods and cut on the microtome. The sections thus obtained proved, in some instances, very successful, especially in the case of such firm tissues as the stipe and the vegetative portions of the lamina.

Several staining fluids were used. Both section-staining and staining *in toto* were employed. The former method proved most successful. The following stains were found useful.

Aniline blue: Sections were placed for 5–10 minutes in a saturated solution of aniline blue (spiritlös) in 50 per cent. alcohol. The walls were stained a deep blue, gelatinous structures and cell contents a light blue. This proved the most useful stain for clearly defining anatomical details.

Hoffman's violet: Sections were stained with a saturated solution of Hoffman's violet in concentrated sulphuric acid. As soon as the section had taken a brown stain they were placed in water and the acid washed out. The protoplasm took a blue stain, the walls were unstained. This method proved useful in staining the protoplasmic connections between the cells.

Fuchsin: Dilute alcoholic solution of fuchsin stained the walls light red, the protoplasmic contents a deeper red.

Iodine in potassium iodide: This stained the floridian starch a dark yellow-brown, the other cell contents a light yellow-brown. It proved very useful in staining the protoplasmic connections between the cells, especially in the gonimoblast filaments.

Gross anatomy (Fig. 1).—The plant consists of a broad, flat, membranaceous, more or less subdivided, blood-red lamina borne upon a short stipe which is sensibly continuous with the lamina. The stipe is expanded below into a small holdfast. The lamina is sometimes nearly entire in outline, ovate, or broadly lanceolate, sometimes very deeply lobed, or divided almost to the base into 2–4 lobes which may be widely divergent. The lamina is 17–40 cm. long and 8–17 cm. wide. The two faces of the frond are in all respects similar. The lamina is perforated by numerous holes ranging from .5 mm. to 10 cm. in length and from .5 mm. to 2 cm. in width. The smallest are almost circular in outline. Those somewhat larger (up to about 5 mm. in diameter) are usually somewhat oval, being elongated in the direction of the long axis of the frond. The larger perforations are of irregular elongated outline. Sometimes these perforations are exceedingly numerous, as many as four or five per square cm. being not uncommon.

In some specimens numerous proliferations are borne on the faces and edges of the lamina and also on the stipe. These are cylindrical bodies, about 1 mm. in diameter, seldom more than 25 mm. long, often flattened somewhat towards the apex and often branched once or twice or deeply lobed at the apex.

In two specimens the upper portions of the laminæ present a peculiar mottled appearance which was at first supposed to be due to the presence of tetraspores. It appears that this is not the cause of the phenomenon noted. This subject will be discussed further under the description of the cystocarp.

The entire stipe was present in only one of the specimens at hand. In this it was 3.5 cm. long, about 1 mm. in greatest diameter, flattened somewhat, parallel to the flat surface of the lamina, passing insensibly into the lamina above, and expanding abruptly below to form the holdfast, which is a small, thin, irregular disk, about 5 mm. in diameter.

All of the specimens have cystocarps scattered irregularly over the entire surface of both sides of the lamina. These are bodies 1–1.5 mm. in diameter, nearly hemispherical, or protruding slightly at the apex, and are extremely numerous, as many as fifteen being often found on one square cm. of the lamina.

Minute anatomy: Lamina.—The lamina consists of pseudoparenchymatous tissue of which two principal areas may be distinguished in the cross-section (a), a central layer of large-celled; and (b) a cortical layer of small-celled tissue (Fig. 2).

(*a*) The cells of the central area are large, generally somewhat flattened parallel to the surface of the frond, isodiametrical in tangential section (Fig. 3). The cells vary greatly in size, the average being 73.5 x 105 mic., while cells occur as small as 6 x 14 mic., and as large as 100 x 200 mic. The largest cells are situated near the central portion of this area, and from them the size of the cells decreases quite regularly towards the more superficial portions. The more superficial cells of this area differ considerably in other respects also, from the central cells. The outer cells are more flattened than the central ones, they are more densely protoplasmic and are filled with grains of floridian starch, while but little starch occurs in the central cells. In this more superficial portion of the central area the protoplasmic connections between the cells of the filaments of which the tissue is composed can be easily made out. They are plainly visible in both stained and unstained preparations, and in both tangential and cross sections. In accordance with the less dense protoplasmic contents of the central cells, the connecting strands are less evident among them, but when the walls of this area are stained, numerous pits are shown penetrating the walls of the central cells (Fig. 3). These pits appear to be of irregular distribution and often more than one are to be observed between the same pair of cells. They can be best observed in a tangential section.

(*b*) The cortical area consists of small cells almost spherical or with the longest diameter perpendicular to the surface of the frond, of quite uniform size (averaging 5.7 x 8.5 mic.), arranged in 1–3 layers, either in filaments perpendicular to the surface of the frond or somewhat irregularly. In a surface view of the lamina they appear entirely irregular in arrangement (Fig. 4). The cells are densely protoplasmic and contain chromatophores.

Stipe.—The general structure of the stipe (Fig. 5) is similar to that of the lamina, but there are numerous special modifications of the several areas. The cells of the central area are elongated somewhat in the direction of the axis of the frond and are somewhat compressed parallel to the compression of the stipe. They are of more uniform size than were those of the lamina, and they were otherwise more nearly uniform than those of the lamina. Their average size is 57 x 86 x 143 mic. The cortical area of the stipe is much thicker than that of the lamina. It is 3–8 cells deep. The cells are larger than the corresponding cells of the lamina (average 14 x 23 mic.) and are conspicuously arranged in filaments running perpendicular to the surface of the stipe.

Proliferations.—The structure of the proliferation is similar to that of the main frond. The central cells are somewhat elongated in the direction of the axis, and, in general, are more numerous and smaller than the corresponding ones of the main frond. All the cells except those of the cortical area contain considerable floridian starch.

Reproductive tract.—Cystocarp (Fig. 7–12). The cystocarp projects on one side of the thallus. The pericarp is composed of thickened cortical tissue, which, in the mature cystocarp, is 8–40 cells thick. The outer walls of the pericarp are small and resemble those of the cortex of the vegetative part of the frond. The inner cells are large (14 x 29 mic.), flattened parallel to the surface of the cystocarp and show numerous irregular protoplasmic connections. The cystocarp opens by a carpostome situated at the apex of the pericarp.

The sporogenous tissue is in the form of an irregularly lobed mass, borne on a basal placenta, and partially filling the cavity of the cystocarp. The space between the spore mass and the pericarp is filled with gelatine. The placenta is a mass of small-celled tissue containing numerous intercellular spaces, which rests upon the large-celled central tissue of the lamina. The gonimoblast filaments (Fig. 9–11) branch repeatedly. They consist of irregular elongated or rounded, often club-shaped cells, with dense, finely granular protoplasm and very transparent walls. They contain no starch. They are connected in filaments by very broad protoplasmic connections surrounded midway by a callous-like ring. The upper cells of the filaments are smaller and more rounded than the lower. The structure of the filaments was best shown in preparations made by pressing out the contents of a mature cystocarp upon a microscopic slide, staining lightly with iodine in potassium iodide, and then pressing out with a cover glass. The spores themselves are irregular, ovoid, thin-walled cells, densely packed with floridian starch. Their average size is 21.5 x 34.5 mic., but they vary considerably in this respect. The number of spores produced in each cystocarp is very great, 20,000–30,000 being not uncommon. The lowest lobes of the sporogenous mass appear to be in all cases sterile. They form small masses of compact tissue consisting for the greater part of cells having about one-half the diameter of mature spores and containing but little starch. A few long cells like those of the gonimoblast filaments also occur in this region.

In many cystocarps branched filaments of cells rise from the vegetative tissue at the base of the cystocarp. The cells of these filaments (Fig. 8) exhibit peculiar lateral outgrowths which appear to fuse with the adjacent cells or with similar outgrowths from them, forming a peculiar loose, irregularly connected tissue similar to that which forms the inner portion of the cystocarp wall. These filaments are not present in all cystocarps. They appear to result from the tearing of the subcortical tissue in the formation of the cavity of the cystocarp.

In the young cystocarp (Fig. 12) the thickened wall is already present and shows its permanent division into two layers. The cells of the outer layer are arranged in filaments perpendicular to the surface, those of the subcortical layer are arranged in oblique rows converging towards the apex of the pericarp. The placental area and spore mass are represented by a few connected cells with very dense contents. The cavity of the cystocarp is, at this stage, comparatively small. The carpostome is already developed even in very young cystocarps. It appears to be formed by the tearing apart of the cells together with the destruction of some of the cells. As was mentioned in the account of the gross anatomy of the lamina, in two specimens the apical portions of the frond present a peculiar mottled appearance. Cross sections of these areas show that in places there are slight protuberances from the surface of the thallus associated with an unusual development of cortical and, in some cases, also of the subcortical cells. The cortical cells are rather narrower than elsewhere, and more elongated perpendicularly to the surface of the frond. The cortical layer is also a greater number of cells deep than elsewhere, and in some cases there is also increase in the number of the smaller central cells situated immediately beneath the cortex. These areas in some cases involve only a few cells, in others they are .5 mm. in diameter. The structure of the larger protuberances agrees essentially with that of the young cystocarp described above, except that in no cases could any cavity be discovered in them. They appear to me to be very young stages of cystocarp development, but in no case could positive evidence of their nature be discovered.

No indubitable cases of tetraspore formation were seen, but in some cross sections taken through the upper part of the lamina, some of the cortical cells are peculiarly divided producing somewhat the appearance of tetraspore formation (Fig. 6). Except for their peculiar arrangement, these cells appear in all respects similar to the ordinary cortical cells. Whether they are tetraspores or not, could not be determined. Their method of division is cruciate or somewhat irregular approaching the tetrahedral arrangement.

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Description of Plate XX.

1. Mature plant showing perforations, proliferations and cystocarps. x $\frac{1}{8}$.

2. Cross section of frond. *Med.* medullary area, *cor.* cortical area. x 112.

3. Longitudinal section of central area of frond, showing pits in the walls. x 132.

5. Surface view of frond, showing irregular arrangement of surface cells. Stained with fuchsin. x 335.

5. Cross section of stipe. Drawn with camera lucida. x 40.

6. Tetraspores ? x 335.

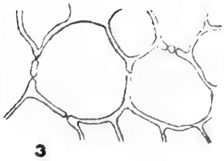
7. Cross section of mature cystocarp (not cut through carpostome) showing placentation and general structure of the spore mass. The upper part of the spore mass is somewhat scattered. Only the spores have their contents filled in. x 39.

8. Peculiarly branched and interwoven filaments from the base of a cystocarp. x 237.

9. Gonimoblast filaments stained one minute in iodine in potassium iodide. x 237.

10, 11. Gonimoblast filaments, contents not drawn. x 237.

12. Young cystocarp showing carpostome and early stage in the development of spore mass. Contents have been omitted except from sporogenous cells. Drawn with Camera lucida. x 230.



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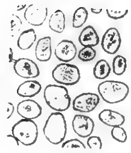

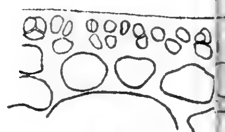

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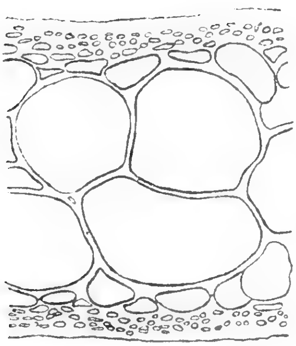

cor

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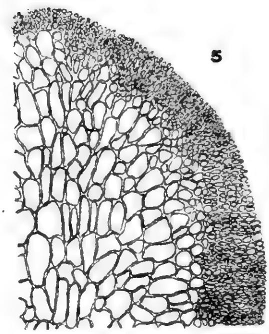

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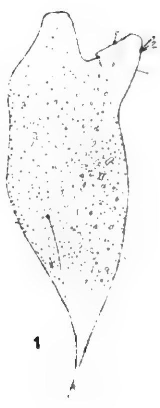

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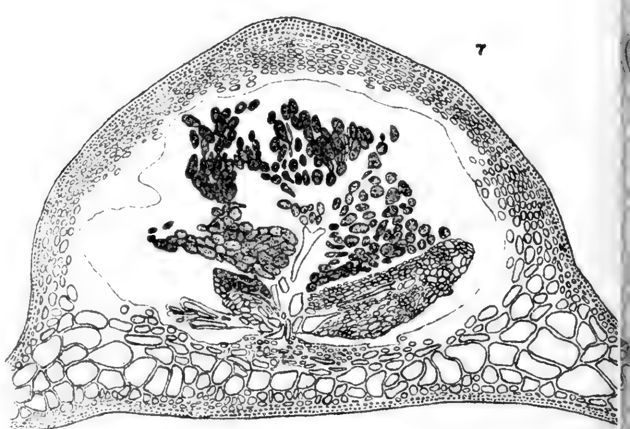

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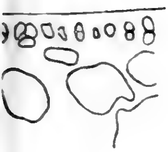

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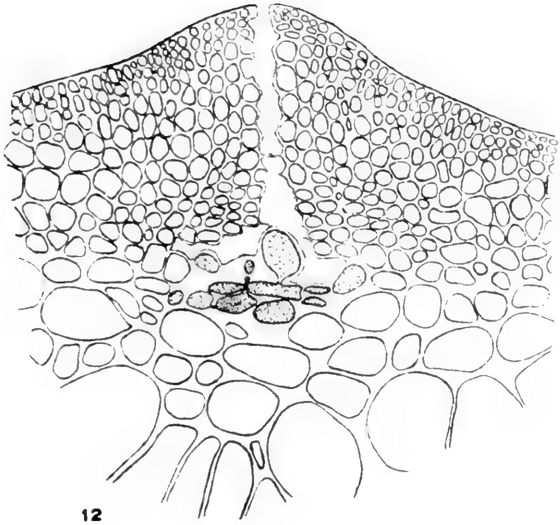

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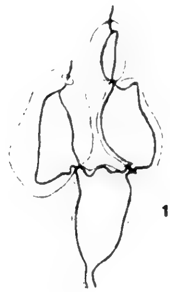

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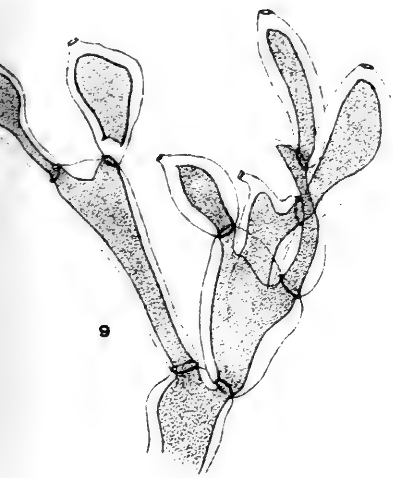

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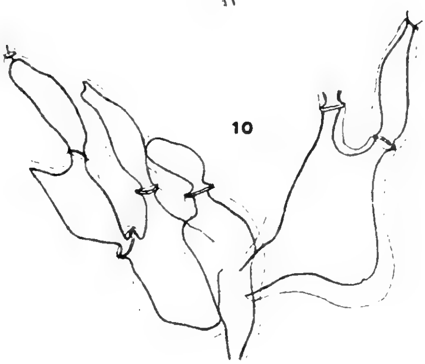

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XX.

XVIII. CONTRIBUTIONS TO A KNOWLEDGE OF THE LICHENS OF MINNESOTA.—IV. LICHENS OF THE LAKE SUPERIOR REGION.

Bruce Fink.

CONSIDERATIONS OF DISTRIBUTION AND HABITAT.

The area treated in this paper includes essentially the counties of Cook and Lake, comprising about 5,000 square miles of land. It lies to the northwest of lake Superior, bordering on the lake for about 150 miles and on the province of Ontario, Canada, for about 125 miles, thus forming the extreme northeastern portion of the State of Minnesota. It was supposed, before studying it, that the region, because of its position, would furnish many lichen species new to the State and to the interior of North America, and the investigation has fulfilled expectations. Besides its geographical position, certain physical features have produced diversity of lichen species as will be shown later.

The lichens of the region have never been studied previously. Tuckerman, in his Synopsis,* mentions collections from the north shore of lake Superior by John Macoun and L. Agassiz. The collections by Agassiz were made in 1848 and published † from 1850 to 1852. He traversed the north shore from Sault Saint Marie to Fort William. The collecting by Macoun was done in July, 1869, along the north shore in Canada, and in 1884 around lake Nipigon. A publication may soon be expected from the latter collector, giving a complete list of the Canadian lichens, and this should add much of interest concerning some species listed in this paper. Of the two collectors, Agassiz, at Fort William, came within about 50 miles, while Macoun probably came within 150 miles of certain points

* Tuckerman, E., Synopsis of the North American Lichens, Parts I and II, 1882 and 1888.

† Agassiz, L., Lake Superior, its Physical Character, Vegetation and Animals compared with those of other and similar Regions, pp. 170–174. Boston, 1850.

reached by me along the international boundary or the shore of the lake.

Several species of the lichens collected by Dr. C. C. Parry in 1848 and published in 1895 * show northern range, but careful investigation † indicates that they were collected south of lake Superior. Thus it appears that the collections listed herein are the first made on the north shore of lake Superior in Minnesota, or along the international boundary for more than 100 miles west of the lake.

The collecting was done by the writer, assisted by Mr. A. S. Skinner, during the latter part of June and the whole month of July, 1897. We were fortunate enough to be associated with Dr. A. H. Elftman, who wished to traverse the region for geological study and whose thorough knowledge of the territory covered, alone made it possible for us to find the best collecting stations in this for the most part uninhabited region, and thus to accomplish good results in a comparatively short time.

We reached Grand Portage island on the north shore of lake Superior, June 16th, and began collecting at once. The plan was to study the lichen flora of the international boundary and the north shore of lake Superior within the boundaries of Minnesota and to reach some of the inland portions of the two counties. On the whole trip we sought localities as collecting stations offering the greatest differences as to elevation, rock formations, arboreal flora, soil, moisture, etc. Beginning at Grand Portage island we traveled westward by Pigeon river and the chain of lakes along the international boundary to Gunflint, thence south by a series of lakes to Poplar river and down the river to Lutsen, on the shore of lake Superior. From here we proceeded down the lake to Tofte, Beaver Bay and Two Harbors. We next went directly to Ely and thence eastward to Snowbank lake. We made as thorough a study as possible of the lichen flora of the Grand Portage area, and then stopped for study whenever and wherever we found enough of difference in

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* Fink, B., Lichens collected by Dr. C. C. Parry in Wisconsin and Minnesota in 1848. Proc. Iowa Acad. Sci. 2 : 137. 1895.

† Parry, C. C., Systematic Catalogue of Plants of Wisconsin aud Minnesota, made in connection with the geological survey of the Northwest during the season of 1848. In Owen, D. D., Report of a geological survey of Wisconsin, Iowa, Minnesota and incidentally of a portion of Nebraska Territory. Appendix, article V. 606–622. 1852, mentions *Cladonia rangiferina* (L.) Hoffm. and *Gyrophora muhlenbergii* Ach. from Falls of St. Croix.

physical environment to lead to the conclusion that time would be profitably employed.

The writer was relieved of camp duty as much as possible, so that there was some time for collecting each day, even when traveling. However, the few collections thus made are nearly all recorded in the list with those of the nearest well studied locality. The principal collecting stations are given below, with elevation and time spent in collecting for each. Since many of these stations are in uninhabited and little known regions, I have given the township and range of each one.

I. Grand Portage and Grand Portage island, 9 days, elevation 602 to 1305 feet, T. 63 N., R. 6 E.

II. English portage, 3 hours, elevation 1339 feet, T. 64 N., R. 4 E.

III. South Fowl lake, 3 hours, elevation 1436–1450 feet, T. 64 N., R. 4 E.

IV. Moose lake, 2 hours, elevation 1492 feet, T. 65 N., R. 3 E.

V. Rose lake, 1 day, elevation 1528 feet, T. 65 N., R. 1 W.

VI. Paulson iron mines, 2 days, elevation 1825 to 2000 feet, T. 65 N., R. 4 W.

VII. Gunflint, 1 day, elevation 1547 to 1650 feet, T. 65 N., R. 3 W.

VIII. Winchell lake, 2 days, elevation 1910 to 2230 feet, T. 64 N., R. 2 W.

IX. Brule lake, 5 hours, elevation 2084 feet, T. 63 N., R. 3 W.

X. Tofte, 3 days, elevation 927 to 1529 feet, T. 59 N., R. 4 W.

XI. Beaver Bay, 2 days, elevation 602 to 1250 feet, T. 55 N., R. 8 W.

XII. Great Palisades, 6 hours, elevation 602 to 1200 feet, T. 56 N., R. 7 W.

XIII. Two Harbors, 2 hours, elevation 692 feet, T. 52 N., R. 11 W.

XIV. Prairie portage, 1 day, elevation 1300 feet, T. 64 N., R. 9 W.

XV. Iron Mountain lake, 1 day, elevation 1342 feet, R. 64 N., R. 8 W.

XVI. Snowbank lake, 4 days, elevation 1424 feet, T. 64 N., R. 9 W.

XVII. Disappointment lake, 1 day, elevation 1449–1850 feet, T. 64 N., R. 8 W.

XVIII. Moose lake, 1 day, elevation, 1339 feet, T. 64 N., R. 9 W.

XIX. Wind lake, 1 day, elevation 1359 feet, T. 64 N., R. 9 W.

XX. Ella Hall lake, 3 hours, elevation 1306 feet, T. 64 N., R. 10 W.

XXI. Fall lake, 3 hours, elevation 1313 feet, T. 63 N., R. 11 W.

Of the stations given above, numbers XIV to XIX inclusive have been designated in the list of species as the Snowbank lake area, XX and XXI as Ely, VIII and IX as the Misquah hills, and VI and VII as Gunflint. All other areas include each but a single station. The quantity-collecting being largely done when we left Grand Portage, we were able to move rapidly, as only plants not found in this first area needed to be collected in bulk. For illustration of distribution, the collections were made as complete as possible at Grand Portage, Gunflint, in the Misquah hills, at Tofte, at Beaver Bay and in the Snowbank lake area.

There is an appreciable difference between the lichen flora of Grand Portage island and that of the mainland two miles across the bay. The island reaches an elevation of only 125 feet above lake Superior while Mt. Josephine on the mainland reaches an altitude of about 800 feet above the lake. The Keweenawan series of rocks, which appears on the island, is wanting on the portion of the adjacent mainland explored, while the Animikie series is found in both places. However, I could not ascertain that difference in petrographical construction in any noticeable way determines the floral differences either here or elsewhere in the territory studied. Passing by the Gunflint area for the present, I may say that the Misquah hills were regarded as especially important, since they contain the highest areas in the state, and were as carefully studied as our time would permit. Carlton peak at Tofte, and the Palisades were points of special interest. Two Harbors was of interest as it is the most southern point reached in the survey, and Ely was, also, as it is the most western. However, the Snowbank lake area somewhat further east was much more thoroughly studied than Ely.

On the whole all of the two counties was studied thoroughly enough to know that practically all of the lichens generally distributed over the area were secured as well as many more which as yet show only local occurrence. Examination of the route will show that we covered all of the international boundary between Ely and Grand Portage, except about 20 miles in a straight line from the most eastern portion of the Snowbank lake area to Gunflint. Thus the boundary was well studied. The line of travel through the Misquah hills from Gunflint to Lutsen gave a fair view of the interior of the region as well as the highest area in the state. A day spent along the shore at Lutsen failed to furnish any species not found at Grand Portage. Consequently, as we were to stop at Tofte, only 10 miles distant, no record was made of the species found at the former place. Tofte, Beaver Bay and the Palisades gave a good view of the lake shore and higher elevations near by in the Sawteeth mountains. It is to be regretted that we did not have opportunity for examination of the lake shore and Sawteeth mountains at some points between Lutsen and Grand Portage, but doubtless the number of additional species would not have been large after a thorough examination of the shore both to the extreme north and toward the south of the area studied.

The whole region is one of extreme interest to the lichenist because of the diversity of natural conditions which gives a flora rich in individuals as well as variations within certain species which attracted special attention. The great masses of igneous and metamorphic rocks along the Superior and inland shore lines, the same rocks back from shore lines and the coniferous and various other trees together with diversity as to temperature, moisture and elevation, all help to produce a flora richer in lichen species than I had expected to find. Though the annual precipitation of moisture for the area is not large, yet the comparatively impervious nature of the rocks causes the water to collect in depressions of surface, forming a multitude of lakes of various sizes whose moist borders are a veritable paradise for lichens and especially for lithophytic species. The dense forests also hold moisture and favor lichen growth. When one finds single branches of *Usnea longissima* Ach. five feet long, as we collected on Grand Portage island, he realizes the significance of the name. Here and in some other localities of the region studied the dying conifers especially are literally covered with this plant, other species of the genus and *Alectoria jubata* (L.) Nyl., all growing in a tangled profusion which obscures the host and when wet with rain or dew furnishes a view of surpassing beauty. Hardly less remarkable is the growth of *Cladonia rangiferina* (L.) Hoffm. in open woods near Mt. Josephine, single clusters measuring three or four feet across and reaching a foot in height. This plant was also common on rocks and in crevices exposed to wind and sun, but was always much smaller in such locations. It is evidently not a natural pioneer among lichens, but grows after other plants have attacked the rocky substratum, or on a thin layer of soil in crevices, and best of all after trees or shrubs have grown sufficiently to protect it somewhat from wind and sun and have not yet become large enough or thick enough to kill it out. This same kind of ecological relation favors *Cladonia furcata* (Huds.) Fr., a variety of which was found fruiting only in such environment. More is given below about other *Cladonias*, and the observation could be extended to *Stereocaulon*.

After fires have passed over a region destroying the trees and small scattered second growth begins to appear to furnish some protection, *Cladonia cristatella* Tuck. and a large variety of forms of *C. gracilis* (L.) Nyl. soon begin to grow in great profusion on old stumps, prostrate logs and bits of decaying wood lying upon, or more or less sunken into the soil. Only a few of the many varieties of the latter plant allowed by European lichenists are recognized in the list of species though forms closely resembling other varieties, so called, are represented in my collections. Nothing seems to be gained by carrying the "splitting" process to extremes without a study of life histories. *C. gracilis* (L.) Nyl. in regions recently burned showed much less variation than in places where the species had been established longer since the burning, and a careful study of a large number of individuals in this region, extending over a series of years would enable one to trace the growth and variation within single individuals and thus establish varieties with certainty. Great variety was observed in the plants in regions that had burned 15 or at most 20 years ago so that a study extending over 10 years should be sufficient to give the desired data.

Like *Cladonia rangiferina* (L.) Hoffm., *C. cristatella* Tuck. is extremely sensitive to environment. In regions where the plants are exposed to sun and wind and in stations of high elevation, the plants are much smaller than in better shaded and less elevated places. The relation of size to amount of protection offered by trees and shrubs may be observed in many places between Gunflint and Lutsen, especially at Gunflint and in the Misquah hills. The effect of elevation, or rather the combined effect of elevation and exposure, was especially noted on Mt. Josephine and on Carlton peak. In both of these places the stunted condition was also noticeable in other *Cladonias* and in lichens belonging to other genera.

The part that lichens play in rock decay and soil formation was studied in a general way in the Grand Portage area, and some of the most noticeable facts are stated below. Grand Portage island contains 57 acres of land and furnishes sufficient variety as to substrata suitable to lichen growth to make the study interesting. The crustaceous lichens furnish most of the species which first gain a footing on the rocks, and of these were found on the island three or four species of *Placodium*, a half dozen or more rock *Lecanoras* as well as a larger number of *Biatoras*, *Lecideas* and *Buellias*. Of the foliaceous lichens the *Umbilicarias* are most characteristically rock pioneers; but these were very rare on the island, which did not furnish the high bluffs that they seek especially. As soon as rock decay has begun, the less strictly crustaceous species begin to appear. Of these *Pannaria microphylla* (Sw.) Delis was especially noticed sometimes growing on quite firm rock, but more frequently on rotten rock or a residual product of rock decay still *in situ* and protected by the lichen though sometimes several inches deep. Next come the typically foliaceous and fruticulose species as the *Peltigeras* and *Cladonias*. Finally enough soil is established so that smaller Spermaphytes and finally trees and shrubs become established, these larger ones in turn furnishing substrata for epiphytic lichens. At the present time, trees grow at one end of the ridge of highest land extending across the island while the other end is bare of trees and soil to a large extent and yet supports many strictly lithophytic lichens. At the shore line one finds amphibious *Endocarpons* and a *Collema* while typically xerophytic species cover the remainder of the island. The analysis could be extended to include a statement of different sorts of woody substrata which result in giving diversity of lichens growing on wood and, indeed, to give a detailed account of substrata including that of each one of the 88 species and varieties listed from the island. But this would lead to more detail than can be undertaken here, and for more minute account I have been compelled to select very small islands, though not offering so much diversity as to substrata, and have even then confined the analysis to the lithophytic and a few epigean species.

For this study of islands three were selected in the Snowbank lake area, and the lithophytic species were carefully noted on two of them and on the other also the decrease in number due to the establishment of an arboreal flora. It is to be regretted that the study could not have been extended to more islands and to include epiphytic and epigean species as well as lithophytic. Island number one is situated in Sucker lake, 30 feet from the shore, in the N. W. 1/4 of S. W 1/4 of S. E. 1/4 of Sec. 1, T. 64 N., R. 9 W. The size of the island is about 70 x 75 feet. The surface is rocky with soil in a few places formed *in situ* or washed in from the lake, so that *Cladonias* were well established. About twenty shrubs were growing on the island and two rather small pines. The species noted in a short time are as follows:

1. **Cladonia rangiferina** (L.) HOFFM.
2. **Cladonia rangiferina** (L.) HOFFM. var. **sylvatica** L.
3. **Cladonia rangiferina** (L.) HOFFM. var. **alpestris** L.
4. **Cladonia pyxidata** (L.) FR.
5. **Cladonia gracilis** (L.) FR.
6. **Cladonia uncialis** (L.) FR.
7. **Stereocaulon paschale** (L.) FR.
8. **Umbilicaria muhlenbergii** (ACH.) TUCK.
9. **Endocarpon fluviatile** DC.
10. **Parmelia conspersa** (EHRH.) ACH.
11. **Parmelia saxatilis** (L.) FR.
12. **Parmelia caperata** (L.) ACH.
13. **Physcia** sp.
14. **Physcia stellaris** (L.) TUCK.
15. **Physcia speciosa** (WULF., ACH.) NYL.
16. **Physcia obscura** (EHRH.) NYL.
17. **Ephebe solida** BORN.
18. **Pannaria microphylla** (SW.) DELIS.

19. **Urceolaria scruposa** (L.) NYL.
20. **Placodium vitellinum** (EHRH.) NAEG. and HEPP.
21. **Lecanora rubina** (VILL.) ACH.
22. **Lecanora cinerea** (L.) SOMMERF.
23. **Buellia petræa** (FLOT., KOERB.) TUCK.

Island number two is in Snowbank lake, 50 feet from the shore, in the N. W. 1/4 N. E. 1/4 of Sec. 29, T. 64 N., R. 8 W. near the outlet of the lake. The size of the island is about 80 x 100 feet, and it is thickly covered with trees and shrubs except in a few spots where *Cladonia rangiferina* (L.) Hoffm. persists. The species listed below for this island are excepting the *Cladonia*, confined to a circle of rock extending around the island and up from the water three inches to one foot. The species are as follows:

1. **Cladonia rangiferina** (L.) HOFFM.
2. **Endocarpon fluviatile** DC.
3. **Parmelia conspersa** (EHRH.) ACH.
4. **Parmelia caperata** (L.) ACH.
5. **Physcia obscura** (EHRH.) NYL.
6. **Leptogium lacerum** (SW.) FR.
7. **Placodium aurantiacum** (LIGHT.) NAEG. and HEPP.
8. **Lecanora subfusca** (L.) ACH.
9. **Lecanora cinerea** (L.) SOMMERF.

Island number three is in Disappointment lake, about 200 feet from the shore, in the N. E. 1/4 of the S. E. 1/4 of S. E. 1/4 of Sec. 33, T. 64 N., R. 8 W. The size is 50 x 75 feet. The surface is rocky, with a few small shrubs growing in crevices, and is literally covered with rock lichens, and a few *Cladonias* and *Stereocaulons* growing along crevices and beginning to spread in one or two places. The following species were easily detected.

1. **Cladonia rangiferina** (L.) HOFFM.
2. **Cladonia rangiferina** (L.) HOFFM. var. **sylvatica** L.
3. **Cladonia pyxidata** (L.) FR.
4. **Cladonia uncialis** (L.) FR.
5. **Cladonia furcata** (HUDS.) FR.

6. **Stereocaulon paschale** (L.) Fr.
7. **Umbilicaria muhlenbergii** (Ach.) Tuck.
8. **Umbilicaria pustulata** (L.) Hoffm.
9. **Endocarpon fluviatile** DC.
10. **Parmelia conspersa** (Ehrh.) Ach.
11. **Parmelia saxatilis** (L.) Fr.
12. **Parmelia caperata** (L.) Ach.
13. **Physcia** sp.
14. **Physcia stellaris** (L.) Tuck.
15. **Physcia cæsia** (Hoffm.) Nyl.
16. **Leptogium lacerum** (Sw.) Fr.
17. **Ephebe pubescens** Fr.
18. **Ephebe solida** Born.
19. **Pannaria microphylla** (Sw.) Delis.
20. **Urceolaria scruposa** (L.) Nyl.
21. **Placodium vitellinum** (Ehrh) Naeg. and Hepp.
22. **Rinodina oreina** (Ach.) Mass.
23. **Lecanora rubina** (Vill.) Ach.
24. **Lecanora cinerea** (L.) Sommerf.
25. **Buellia petræa** (Flot., Koerb.) Tuck.

Comparing the lichens easily detected on islands numbers one and three—those which give character to the flora—whatever rare species may have escaped notice, we find that, of a total of 23 species and varieties on the first and 25 on the second, 19 are common to both islands, separated by several miles. The lists as a whole show a large number of foliaceous and fruticulose species; and we evidently have not the primitive post-pleistocene lichen population of these rocky islands, which indeed must have disappeared centuries ago. It is the more remarkable that practically the same species have succeeded in replacing a former flora on the two islands. I regret that time was wanting for the study of more of these islands, and especially of some farther from the shore line. The growth of larger forms of vegetation is probably beginning to effect a decrease in lichen species on island number one for otherwise, being larger, it should have furnished more species than number three rather than a smaller number. But it was only on number two that we found the unmistakable evidence of the effects of the arboreal vegetation in exterminating the lichens. Here too the species existing are all but two the same as those found on one or both of the other islands, but the number is reduced to little more than one-third as many as occur on either of them.

The succession of species is as apparent upon trees as upon rocks and is constantly in evidence in this largely undisturbed region where trees of various ages grow side by side. Some of the crustaceous lichens, of such genera as *Pyrenula*, *Arthonia* and *Graphis*, were usually found on young trees with smooth bark. As the substratum becomes more rugged with the increasing age of the tree, these are gradually replaced by foliaceous and fruticulose species as *Ramalinas*, *Usneas*, *Parmelias*, etc. Finally as the trees die certain species of *Calicium Cladonia*,*Peltigera*, *Parmelia*, etc., become the dominant types. It is not possible, nor is it necessary here, to give a detailed account of relation between each epiphytic lichen and its host, but a few of the most apparent relationships are in order. *Acer spicatum* Lam. supports *Arthonia dispersa* (Schrad.) Nyl. over the whole area. *Populus tremuloides* Michx. and *P. balsamifera* L. bear *Pyrenula leucoplaca* (Wallr.) Kbr. commonly. Some conifers, as *Pinus resinosus* Ait., *P. strobus* L., *Thuja occidentalis* L., serve for substrata for those species of the genus *Calicium* which grow on living trees. The most luxuriant growths of *Usnea* were found on *Picea mariana* (Mill.) and *Abies balsamea* (L.) Mill. *Graphis scripta* (L) Ach. var. *recta* (Humb.) Nyl. was almost wholly confined to *Betula lutea* Michx. and this same tree also supports *Sagedia oxyspora* (Nyl.) Tuck and two or three *Pyrenulas*.

A close analysis of the distribution of species within the area studied reveals much of interest even though it is a rather a restricted region. Of the 258 species and varieties listed, 96 were found only in one place, 32 in two, 31 in three, and the remaining 99 were collected along lake Superior and also inland, in four or more localities and are known to be generally distributed over the whole of the two counties. Also of those found in in two or three localities, 34 species were collected at some point along lake Superior and also beyond the ridge of high land formed by the Mesabi range and the Misquah hills and are doubtless quite generally distributed over the territory surveyed. Of these found in two or three places, 13 more were found along the lake and inland, but none beyond the divide mentioned above. These are doubtless generally distributed between this highest land and lake Superior, and of course may occur northwest of this high area as well.

Of course the 133 or more species most generally distributed over the area largely determined the character of its flora and are interesting in studying the relation of the flora of the region to that of others. But for the study of distribution within the area, as influenced by natural conditions, the chief interest centers around the 96 species found in one place only and those found in two or three areas and yet not generally distributed over the whole region. I give below a list stating the whole number collected in each principal collecting ground and also the number found at each one and not elsewhere. It will readily be seen that the last datum for each locality simply bears a close relative proportion to the first, or in other words, that no one area shows a large relative proportion of the rare species. Of course the data as to occurrence of these rare lichens can not be relied on fully; but about two-thirds of them are species of size large enough to be easy of detection, and while these may occur in other places, they are surely not common in the area. The table of species is as follows:

Grand Portage island,	total	collected,	88,	not	found	elsewhere,	15
Grand Portage,	"	"	59,	"	"	"	12
South Fowl lake,	"	"	14,	"	"	"	1
Rose lake,	"	"	20,	"	"	"	3
Gunflint,	"	"	118,	"	"	"	12
Misquah hills,	"	"	115,	"	"	"	11
Tofte,	"	"	85,	"	"	"	8
Beaver Bay,	"	"	82,	"	"	"	13
Palisades,	"	"	33,	"	"	"	1
Two Harbors,	"	"	14,	"	"	"	2
Ely,	"	"	41,	"	"	"	3
Snowbank lake area,	"	"	121,	"	"	"	15

The rather high per cent. of forms collected at Grand Portage only is due to the fact that the attempt was made to collect here especially species not found on the island. At an average about one-eighth of the species collected in each locality were not found elsewere. As stated above, two-thirds of these are conspicuous forms. The remaining one-third are some of the less conspicuous *Biatoras*, *Lecideas*, *Buellias*, *Graphises*, *Pyrenulas*, etc., which are not easily found.

When we consider the limited size of the area studied, the restriction of certain of the rarer species to certain parts of it rather than to others is worthy of careful study. The area lies on two sides of a divide extending approximately east and west and formed of the Mesabi range and the Misquah hills. The alpine or sub-alpine species not generally distributed over the area are mostly confined to the portion lying between the divide and lake Superior and to the Misquah hills on the divide, and also those found along the lake are for the most part found toward the northeastern portion of the territory traversed. The rarer temperate region species on the other hand are most numerous to the north and west of the divide, or toward the south of the portion between the lake and the divide. All of the data given above as to distribution within the area studied are based upon carefully prepared lists showing the distribution of each species. They can not all be reproduced, but parts of them must be. First of all, the facts concerning the species found only in one place can only be properly presented for consideration by the somewhat laborious table below, giving the various localities and species for each.

GRAND PORTAGE ISLAND.

Usnea cavernosa TUCK., N.

Physcia hispida (SCHREB.) FR., N.

Solorina saccata (L.) ACH., N.

Lecanora calcarea (L.) SOMMERF. var. **contorta** FR., T.

Cladonia gracilis (L.) NYL. var. **symphycarpia** TUCK., T.

Cladonia squamosa HOFFM. var. **phyllocoma** RABENH., T.

Cladonia deformis (L.) HOFFM., N.

Bæomyces byssoides (L.) SCHAER., N.

Biatora turgida (FR.) NYL., T.

Lecidea spirea ACH., N.

Endocarpon miniatum (L.) SCHAER., T.

Lecidea crustulata ACH., N.

Lecidea enteroleuca FR. var. **achrista** SOMMERF., T.

Staurothele drummondii Tuck., T.
Pyrenula cinerella (Flot.) Tuck., T.

Grand Portage.

Parmelia perforata (Jacq.) Ach. var. **hypotropa** Nyl., T.
Physcia adglutinata (Floerk.) Nyl., T.
Umbilicaria hyperborea Hoffm., N.
Nephroma lævigatum Ach. var. **parile** Nyl., N.
Placodium murorum (Hoffm.) DC. var. **miniatum** Tuck., T.
Lecanora muralis (Schreb.) Schaer var. **diffracta** Fr., T.
Biatora leucophæa Floerk. var. **griseoatra** Koerb., N.
Biatora lucida (Ach.) Fr., N.
Lecidea lapicida Fr. var. **oxydata** Fr., N.
Thelocarpon prasinellum Nyl., T.
Verrucaria nigrescens Pers., T.
Pyrenula cinerella (Flot.) Tuck. var. **quadriloculata** var. nov. (?).

South Fowl lake.

Alectoria sæpincola (Ehrh.) Ach., N.

Rose lake.

Heterothecium sanguinarium (L.) Flot. var. **affine** Tuck., N.
Opegrapha varia (Pers.) Fr. var. **notha** Ach., T.
Usnea barbata (L.) Fr. var. **dasyopoga** Fr., T.

Gunflint.

Physcia cæsia (Hoffm.) Nyl., T.
Pannaria nigra (Huds.) Nyl., T.
Placodium cinnabarrinum (Ach.) Anz., T.
Lecanora pallida (Schreb.) Schaer., T.
Lecanora hageni Ach., T.
Cladonia symphycarpa Fr. var. **epiphylla** (Ach.). Nyl., T.
Cladonia fimbriata (L.) Fr., T.
Cladonia gracilis (L.) Nyl. var. **cervicornis** Floerk., T.
Biatora glauconigrans Tuck., T.

Lecidea acclinis FLOT., T.

Buellia petræa (FLOT., KOERB.) TUCK. var. grandis FLOERK., N.

Arthonia patellulata NYL., T.

MISQUAH HILLS.

Parmelia centrifuga (L.) ACH., N.

Collema flaccidum ACH., T.

Placodium murorum (HOFFM.) DC., T.

Lecanora subfusca (L.) ACH. var. hypnorum SCHAER., T.

Pertusaria glomerata (ACH.) SCHAER., N.

Biatora oxyspora (TUL.) NYL., T.

Biatora schweinitzii FR., T.

Lecidea lapicida FR., N.

Lecidea albocærulescens (WULF.) SCHAER., N.

Lecidea platycarpa ACH., N.

Graphis scripta (L.) ACH. var. limitata ACH., T.

TOFTE.

Parmelia perforata (JACQ.) ACH., T.

Sticta limbata (SM.) ACH., N.

Leptogium myochroum (EHRH.) SCHAER., T.

Lecanora elatina ACH., T.

Stereocaulon coralloides FR., N.

Cladonia cæspiticia (PERS.) FL., T.

Cladonia digitata (L.) HOFFM., N.

Calicium chrysocephalum (TURN.) ACH. var. filare ACH., T.

BEAVER BAY.

Ramalina calicaris (L.) FR. var. fastigiata FR., T.

Ramalina pollinarella NYL., T.

Placodium cerinum (HEDW.) NAEG. and HEPP. var. pyracea NYL., T.

Placodium vitellinum (EHRH.) NAEG. and HEPP., T.

Lecanora calcarea (L.) SOMMERF., T.

Cladonia mitrula Tuck., T.

Cladonia delicata (Ehrh.) Fl., T.

Cladonia decorticata Floerk., T.

Biatora coarctata (Sm., Nyl.) Tuck., T.

Biatora myriocarpoides (Nyl.) Tuck., T.

Biatora nægelii Hepp., T.

Buellia myriocarpa (DC.) Mudd., T.

Sagedia oxyspora (Nyl.) Tuck., T.

Palisades.

Cetraria islandica (L.) Ach., N.

Two Harbors.

Physcia aquila (Ach.) Nyl., T.

Buellia dialyta (Nyl.) Tuck., T.

Ely.

Lecanora tartarea (L.) Ach., T.

Buellia myriocarpa (DC.) Mudd. var. polyspora Willey., T.

Calicium trichiale (Ach.) var. stemoneum Nyl. T.

Snowbank lake area.

Ramalina calicaris (L.) Fr. var. canaliculata Fr., T.

Ramalina pusilla (Prev.) Tuck., N.

Parmelia tiliacea (Hoffm.) Floerk. var. sublævigata Nyl., T.

Collema pycnocarpum Nyl., T.

Leptogium lacerum (Sw.) Fr., T.

Leptogium lacerum (Sw.) Fr. var. pulvinatum Moug. and Nestl., T.

Rinodina sophodes (Ach.) Nyl. var. confragosa Nyl., T.

Gyalecta fagicola (Hepp.) Tuck., T.

Biatora sphæroides (Dicks.) Tuck., T.

Biatora fuscorubella (Hoffm.) Tuck., T.

Biatora muscorum (Sw.) Tuck., T.

Lecidea cyrtidia Tuck., T.

Buellia parmeliarum (Sommerf.) Tuck., T.

Coniocybe pallida (PERS.) FR., T.

Verrucaria epigæa (PERS.) ACH., T.

In the above table all of the arctic and subarctic species are marked (N.) and the species common in temperate regions at low elevations (T.). Beginning then with the areas between the divide formed by the Mesabi range and the Misquah hills and lake Superior and toward the north of this region, of a total of 15 species found only on Grand Portage island, seven or one less than half are characteristic of northern regions. Of 12 confined to Grand Portage, five or about 42 per cent. are northern species. A single one collected only at South Fowl lake and one of three at Rose lake are also northern. Of the 12 found only at Gunflint and the 15 found only in the Snowbank lake area, only one strictly northern species is restricted to each place, while for Ely of the three restricted species not one is northern. Consideration of the figures will show that for the five localities along the international boundary there is a decrease in proportion of rare arctic or alpine species in passing westward along the boundary. Again passing southward from Grand Portage we found three northern of a total eight species confined to Tofte, and the one species taken only at the Palisades is northern. The thirteen species found only at Beaver Bay and the two collected only at Two Harbors are all distinctly temperate region plants. Thus it appears that the northern species give way to those more characteristic of temperate regions in passing southward even along the shores of lake Superior where the cold lake winds have greatest influence upon the flora. An elevation of more than 1,000 feet was reached at Beaver Bay without finding northern species while at Grand Portage about 150 miles northeast they descend to the lake level. At Tofte a short distance northeast of Beaver Bay we reached an elevation of 1,529 feet on Carlton peak in the Sawteeth mountains and found three northern species. Only one of the three species was taken at the summit of Carlton peak, but this is because the top of the peak is burned over. The other two species were collected at a considerable distance above the base of the peak and are doubtless to be found on unburned portions of the Sawteeth mountains near by.

In the discussion of the table thus far the Misquah hills area has not been considered. As stated elsewhere this area is the highest portion of the State, reaching 2,230 feet, and the region gave five arctic or subarctic species of a total of eleven collected only here. The influence of elevation becomes apparent when we compare the Misquah hills area with the Gunflint region as to number of northern species. The latter locality lies 20 miles north of the former and about 400 feet lower, only a small portion of it near the Paulson mines reaching 2,000 feet. The Misquah hill area which is a more extended region of higher elevation furnished the goodly proportion of northern forms noted above while the Gunflint area gave only one such species in a total of twelve found only in the area.

Of all the species found only in one place 25, or more than one-fourth, are arctic or subartic and 71, or approximately three-fourths are plants characteristic of temperate regions. Without entering into the yet more complicated analysis which a consideration of these rare temperate region plants would involve, a mere inspection of the table will show in a general way that their distribution is just the reverse of that of the northern species, or that they are especially characteristic of that small portion of the region studied which lies to the north of the divide and of the southern portion of the region lying between the divide and lake Superior. Of course it could also be shown that they are more especially characteristic of the lower elevations.

Of the 63 species collected only in two or three places, only a half dozen are arctic or subarctic species, and it would have been useless to give the whole 63 in tabular form as no safe data could be obtained from so small a proportion of northern species. However, the 6 northern species are as follows:

Ramalina pusilla (Prev.) Tuck. var. **geniculata** Tuck.

Parmelia encausta (Sm.) Nyl.

Sticta scorbiculata (Scop.) Ach.

Lecanora frustulosa (Dicks.) Mass.

Lecanora sordida (Pers.) Th. Fr.

Buellia geographica (Pers.) Tuck.

In order that we may have all of the northern species before us for a final consideration, I shall give a list of those generally distributed as follows:

Lecidea lactea Fl.

Buellia petræa (FLOT., KOERB.) TUCK.

Buellia petræa (FLOT., KOERB.) TUCK. var. **montagnæi** TUCK.

Umbilicaria vellea (L.) NYL.

Nephroma tomentosum (HOFFM.) NECK.

Pannaria lepidiota TH. FR.

Stereocaulon paschale (L.) FR.

Cladonia amaurocræa (FL.) SCHAER.

Bæomyces æruginosus (SCOP.) DC.

Heterothecium sanguinarium (L.) FLOT.

Taking into account the above table, we find that of a total of 99 species and varieties generally distributed over the area studied only 10, or one-ninth, are arctic or subarctic, and considering both of the last two tables we see that of 162 species and varieties more or less widely distributed 16, or nearly one-ninth, are arctic or subarctic. It has been stated that about one-fourth of the species found only in one place are such northern forms. Thus we find that the more general the distribution of a series of plants in the area the smaller the per cent. of northern species, and conversely the larger the per cent. of temperate region species. In other words the prevailing species are those characteristic of temperate regions, and as a whole the rarer ones are the more northern floral elements. Since the introduction of new species is commonly a more rapid process than the complete extermination of others in a given region, the existing conditions above stated seem to prove, as one would naturally suppose, that the present lichen flora of the region is in general of temperate region elements and that the more northern elements of the flora are the persisting for most part in a few favorable spots. This supposition also explains the existence of the northern species in isolated regions further south as I have done for Taylors Falls. Professor Conway MacMillan has considered the spermaphytic flora of this region as a south-bound one,* or at least that of the portion between the divide and lake Superior. My observations here and at Taylors Falls do not indicate that this is generally true of the lichens. However, because of somewhat milder temperature, lower elevation and perhaps more early retreat of the ice sheet in the western half

* MacMillan C. Observations on the distribution of plants along the shore at Lake of the Woods. Minn. Bot. Stud. 1 : 954. 1897.

of the State, the temperate region lichens have no doubt driven or followed the northern species farther north there and doubtless very few of the latter elements now exist in western Minnesota south of Lake of the Woods, or indeed anywhere in the western half of the state. Since gaining possession of the northwestern part of the state these temperate region lichens have doubtless been moving southward over the Mesabi range to meet similar floral elements of a generally northward bound lichen flora. The western half of the state remains to be explored for lichens, but the above statement as to the character of the flora, based on observations recorded in this paper for localities north of the Mesabi range and some knowledge of the general character of the region, I regard as sufficiently secure.

Like the Taylors Falls region this one of course at one time contained only arctic species, and the present more numerous species characteristic of temperate regions have gained the ascendency in quite recent time. However, the problems involved in the struggle betwen the contending floral elements do not force themselves upon the observer so strongly in this larger area and must be dismissed with a much briefer statement. As in the Taylors Falls region the persisting northern species are largely lithophytic. This is shown in the following exhibit of substrata for the 42 species :

Arctic or subarctic lichens confined to	rocks	25
" " " " " "	trees	8
" " " " " "	earth	4
" " " " " "	dead wood	2
" " " " " "	dead wood and trees	1
" " " " " "	earth and rocks	1
" " " " " "	trees " "	1

The greater persistence of the lithophytic species is doubtless due in part at least to the greater stability of the rock surfaces and also probably in part to the fact that the arctic and subarctic species became more thoroughly established on the rocks, which were present for them to attack immediately at the close of the Pleistocene before the advent of large trees and temperate-region lichens.

Thus far I have given a detailed account of habitat for the northern species only. Of the whole 258 species and varieties listed in this paper, so far as observation showed, 83 are epiphytic, 80 lithophytic and 29 may occur on either trees or rocks. Another 29 are epigean, 22 were found only on dead wood, six are lithophytic or epigean, three are found on earth and dead wood, three are parasitic on other lichens and two were found on living and dead wood. The above analysis of substrata is somewhat different from that used in the second paper of this series for comparison of substrata at Minneapolis and at Fayette, Iowa; but when reduced to that form shows that the percentage of lichens growing on rocks is somewhat higher than that for the two areas farther south, while the percentage of those growing on wood is considerably lower. The larger proportion of rock lichens in the Superior region is due to at least three things. First, the more extensive exposure of rock surfaces, though this is offset in part at least by the existence of three distinct kinds of rock in the Minneapolis region, viz.: the igneous or metamorphic boulders, the limestone outcrops and the Saint Peter sandstone. Second, the rock surfaces become warmer, each day in the warm portion of the year, than the trees, because of rapid absorption of heat; and this doubtless favors lichen development on rocks in this northern region. Third, general moisture of much of the surface due to the fact that the rocks are comparatively impervious to water, so that much of it collects in lakes and swamps, favors good development of rock lichens as compared with the region about Minneapolis. At Minneapolis unshaded rocks bear very few lichens, but in the Superior region rocks are well populated with them at all elevations and in all sorts of environment at or above the water line, except where killed by fire.

The total number of genera for the region is 39, while the number for Minneapolis and Taylors Falls, so far as is known, is 34. The whole number for Illinois, as given by Wolf and Hall* is 40 and for Iowa as recorded by the writer in two papers† is 38. This total number of genera for the Superior region is seen by the comparisons with both larger and smaller areas further south to be rather large for a somewhat limited northern

* Wolf, John and Hall, Elihu. A List of the Mosses, Liverworts and Lichens of Illinois. Bull. Ills. State Lab. Nat. Hist. 2: 18–34. June, 1878.

† Fink B. Lichens of Iowa. Bull. Lab. of Nat. Hist., State Univ. of Iowa 3: 70–88. Mr. 1895, and Notes concerning Iowa Lichens, Proc. Iowa Acad. Sci. 5: 174–187. 1897.

area, but a locality where northern and more temperate floral elements meet seems to compensate fully at least for difference in latitude.

The genera giving most of the species new to the state are the following, given in tabular form with the total number of species collected in each genus and the number new to the state.

Ramalina,	collected	6,	new	to the	State	4.
Cetaria,	"	7,	"	"	"	5.
Sticta,	"	5,	"	"	"	3.
Nephroma,	"	4,	"	"	"	3.
Solorina,	"	1,	"	"	"	1.
Lecanora,	"	25,	"	"	"	15.
Gyalecta,	"	1,	"	"	"	1.
Bæomyces,	"	2,	"	"	"	2.
Biatora,	"	23,	"	"	"	16.
Heterothecium,	"	2,	"	"	"	2.
Lecidea,	"	12,	"	"	"	9.
Calicium,	"	9,	"	"	"	9.
Coniocybe,	"	1,	"	"	"	1.
Sagedia,	"	1,	"	"	"	1.

Of these genera *Solorina*, *Bæomyces*, *Heterothecium*, *Calicium*, *Coniocybe*, and *Sagedia* are new to the State. An inspection of the above list shows that the genera are for the most part those furnishing large numbers of arctic and subarctic species, or species hitherto supposed to be confined to New England. The genera *Stereocaulon* and *Umbilicaria* are equally characteristic of northern and eastern areas, but two-thirds of the species of these genera here recorded were listed for Minnesota in the first paper of this series.

By comparing the present list of species and varieties with those recorded for Minneapolis and Taylors Falls we find that that there are 152 lichens growing in the territory considered in this paper and not found in either of the two areas named above, while there are 33 found in them and not in the northeastern Minnesota area under consideration. This leaves only 73 lichens known to be common to central and northeastern Minnesota. In the comparison between Minneapolis and certain localities in northeastern Iowa it was shown that no species have been found at the former place and not in the latter region, though Minneapolis is 150 miles north of Fayette, the principal Iowa area considered. In passing about 200 miles north from

Minneapolis, on the other hand, we find a lichen flora, about three-fifths of whose species and varieties are not found at Minneapolis and about half of which are new to the state. The region of rapid transition in lichen species lies between the Minneapolis and Superior areas and has only been touched in the study of its rock lichens at Taylors Falls. As stated in the third paper of this series, this region is one of special interest for tracing the distribution of species. The cause of the great difference in lichen flora between Minneapolis and the Superior region is scarcely due in any great measure to difference in latitude since an almost equal difference in latitude to the south of Minneapolis caused no appreciable difference in the flora. Also, I have shown in this paper that in three localities lying in the northern part of the region studied in the paper, viz.: Snowbank lake, Ely and Gunflint, very few typically northern species are found. These regions at the north of the area are more closely related to the Minneapolis region as to lichen flora than others 50 or 75 miles further south. The difference in lichen flora between central and northeastern Minnesota seems then to be due chiefly to three factors. The first is difference in substrata. The limestones of the Minneapolis regions, as well as the sandstone, are almost entirely wanting in northeastern Minnesota, being replaced by an abundance of igneous or metamorphic rocks. The conifers, which abound in the northern part of the State, and which serve for substrata for quite a number of species not found southward, form the other chief difference as to substrata. Location in the valley of lake Superior, where the region is shut off from warmer regions west and north as well as south, is another factor that has caused much of the difference in flora. It has been shown that the number of arctic and subarctic species for a given elevation decreases in passing southwestward along the lake. This I suppose to be due not so much to difference in latitude as to the fact that in the northeastern part of the region studied along the lake the winds coming from the broader expanse of water, on this largest American fresh water area, are rendered cooler than farther down where the lake is not so wide. That the cold winds are a factor is demonstrated by the occurrence of a large proportion of northern species at the Grand Portage area, and especially on the island which rises little more than 100 feet above the lake, while such inland areas as Gunflint and Snowbank lake, which are somewhat farther north, are almost entirely devoid of such species. A third factor is increase in elevation. The influence of elevation has been discussed in considering the Misquah hills and the Sawteeth mountains. Concerning cold lake winds and elevation, it is significant that of the 25 arctic and subarctic species found only in one place, 16 are found at stations along the lake, and that of the remaining 9, 5 are found in the Misquah hills, the region of highest elevation. Thus all but 4 of these 25 species were collected where one or both of these factors have most influence.

It is not possible to state just which ones of the many species found either in central or in northeastern Minnesota and not in the other area would be of most interest in studying the territory lying between the two regions. Of course, the foliaceous and fruticulose species are most easily found, and some of these are most likely to be collected. I may add that interest would centre chiefly about species which are common and give character to the flora in one of the two areas and are not found in the other. Not attempting to select from some 150 species collected in the Superior area and not farther south in the state, I will name, from 27 or 28 species found to the south and not to the north of the unexplored area, *Theloschistes concolor* (Dicks.) Tuck. and *Physcia granulifera* (Ach.) Tuck. as two species that any botanist can soon learn to distinguish in the field, which are common in the south half of Minnesota and not known farther north in the state, and whose distribution between Minneapolis and Two Harbors would be of special interest. Nearly all of the remainder of the 27 or 28 species are either infrequent or rare about Minneapolis, are confined to substrata not existing in northeastern Minnesota, or are so inconspicuous as to render their study in the field difficult.

As a fitting close to these observations on the distribution of lichens in different regions of the state I may give some notes concerning certain species for most part characteristic of more southern portions and found also in northeastern Minnesota. *Parmelia borreri* Turn. was not found fruited along the lake north of Beaver Bay. *Peltigera aphthosa* (L.) Hoffm. seeks high ground in the southern stations from which it is recorded and in the northwestern as well and is one of the species whose farther southern and western extent in the state would be especially worthy of study. *Parmelia tiliacea* (Hoffm.) Tuck. becomes somewhat common at the southwest and more so at the northwest portion of the territory studied. It is one of the southern intrusions which extend farther north at some distance from lake Superior. Trees common farther south in Minnesota were noted north of the Mesabi range as *Quercus macrocarpa* Michx. *Cratægus* sp. and *Fraxinus* sp. On *Fraxinus* was found *Coniocybe pallida* (Pers.) Fr. which is common in northeastern Iowa, and on the same host *Pyrenula leucophaca* (Wallr.) Kbr. also becomes common for the first time in this northern area. Other lichens in the list of those found only north of the Mesabi range or the Misquah hills could be selected for special treatment, and on the whole this portion of the Superior region shows a closer floral connection with central Minnesota than does the most southern point reached, viz., Two Harbors.

The list of 258 species and varieties is a large one for a rather limited area to yield, especially when it is stated that only about 300 lichens have been listed for Minnesota, including the present list. Yet the undisturbed portions of the region are more remarkable for richness in individuals than for large numbers of species. The Grand Portage area gave 132 species and varieties and the Snowbank lake area 121. These two areas are the ones best studied and are perhaps as thoroughly explored as the Minneapolis area, which gave 113 species and varieties. Both of the former two are like the latter small areas and the comparison seems to indicate that the lake Superior region is, area for area, only slightly richer in species than the Minneapolis region. Professor L. H. Bailey* found that the species of *Spermaphytes* and higher *Archegoniates* of the region are only about one-tenth as numerous at lake Vermilion as in similar areas six degrees farther south, and we should of course expect some decrease in lichen species rather than an increase in passing northward in the state. The reverse condition existing is largely due to diverse conditions within the region as to elevation and temperature and as to surface moisture, all of which factors have been duly considered. The Snowbank lake area studied is a larger one than the Grand Portage. About equal time was spent at the two places, and we did much more of the time-consuming quantity-collecting at Grand Port-

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* Bailey, L. H., in Arthur, J. C. Report on botanical work in Minnesota in 1886. Geol. and Nat. Hist. Surv. of Minn., Bull. 3 : 8. 1 O., 1887.

age. Yet fewer forms of lichens were collected about Snowbank lake. This seems to indicate that the lake shore is richer in lichen species than in interior areas of the territory studied.

It is well known that a large portion of the species of lichens of the interior of North America are those found also in regions bordering upon the Atlantic ocean along our eastern border. This was brought out by the writer in a previous paper,* but all the species recorded in that paper were temperate region lichens. It has remained for the present paper to record a large number of more northern lichens previously for the most part known only in arctic or subarctic regions, or descending from mountains farther south only along our Atlantic border.

Of the 258 species and varieties listed below 46 are new to the North American interior or to the interior of the United States, and of these six are new west and north of New England. In treating of distribution the expression "the interior of North America" means the area lying between the Appalachian system of mountains on the east and the Rocky Mountains on the west. A number of species noted as new to the interior have been reported from New York or Canada, and doubtless a few of them were previously found a short distance west of the Appalachian system of mountains.

LIST OF SPECIES AND VARIETIES.

1. **Ramalina calicaris** (L.) FR. var. **fastigiata** FR.
On trees, rare. Beaver Bay, July 13, 1897, no. 677.

2. **Ramalina calicaris** (L.) FR. var. **canaliculata** FR.
On trees, rare. Snowbank lake area, July 23, 1897, no. 895. Not previously reported from Minnesota.

3. **Ramalina calicaris** (L.) FR. var. **farinacea** SCHAER.
On rocks, common or frequent over whole area and rarely found on trees also. Grand Portage island, June 23, 1897, no. 106. Gunflint, June 30, 1897, no. 257. Misquah hills, July 3, 1897, no. 419, and July 7, 1897, no. 539. Tofte, July 10, 1897, no. 624. Palisades, July 15, 1897, no. 763. Snowbank lake area, July 24, 1897, no. 934.

All except no. 763 were lighter colored than other forms of the species. No. 106 occasionally and no. 763 quite commonly

* Fink, B. Lichens of Iowa. Bull. Lab. of Nat. Hist., State Univ. of Iowa. 3: 70–78. Mr., 1895.

are irregularly branched and with dilated terminal soredia like *R. pollinaria* (ACH.) TUCK.

4. **Ramalina pusilla** (PREV.) TUCK.

On trees, frequent. Grand Portage island, June 19, 1897, no. 34. Snowbank lake area, July 20, 1897, no. 844.

Not previously reported from Minnesota and new to the interior of North America.

5. **Ramalina pusilla** (PREV.) TUCK. var. **geniculata** TUCK.

On trees, infrequent or rare. Gunflint, July 2, 1897, no. 375. Beaver Bay, July 13, 1897, no. 675.

Not previously reported from Minnesota and new to the interior of the United States.

6. **Ramalina pollinarella** NYL.

On rocks, rare. Beaver Bay, July 13, 1897, no. 681.

Not previously reported from Minnesota and new to the interior of North America.

7. **Cetraria aurescens** TUCK.

On trees, rare. Tofte, July 10, 1897, no. 636. Snowbank lake area, July 21, 1897, no. 869.

Not previously reported from Minnesota and new to the interior of North America.

8. **Cetraria islandica** (L.) ACH.

On earth above the Palisades, rare, July 15, 1897, no. 765.

Not previously reported from Minnesota.

9. **Cetraria ciliaris** (ACH.) TUCK.

On trees, abundant on Grand Portage island, elsewhere only rare or frequent. Grand Portage island, June 18, 1897, no. 10. Gunflint, July 2, 1897, nos. 387 and 396 at Misquah hills, July 3, 1897, no. 427. Snowbank lake area, July 22, 1897, no. 883, and July 26, 1897, no. 948. Ely, July 28, 1897, no. 1022.

10. **Cetraria lacunosa** ACH.

On trees, common. Top of bluff at south end of South Fowl lake, June 26, 1897, no 206. Gunflint, July 2, 1897, no. 401. Misquah hills, July 3, 1897, no. 442. Tofte (Carlton peak), July 10, 1897, no. 556. Beaver Bay, July 14, 1897, no. 733. Snowbank lake area, July 21, 1897, no. 946.

Not noted at Grand Portage where the last above was abundant, but seeming to replace it in part elsewhere, being common in the localities noted above.

11. **Cetraria juniperina** (L.) ACH. var. **pinastri** ACH.

On trees and old logs. Common at Grand Portage and Misquah hills, elsewhere infrequent or rare, sterile. Grand Portage island, June 18, 1897, no. 15. Gunflint, June 30, 1897, no. 261. Misquah hills, July 3, 1897, no. 411. Beaver Bay, July 13, 1897, no. 679. Snowbank lake area, July 21, 1897, no. 865. Ely, July 28, 1897, no. 1016.

Not previously reported from Minnesota and new to the interior of North America.

12. **Cetraria sæpincola** (EHRH.) ACH.

On trees, rare. South Fowl lake, June 27, 1897, no. 201.

Not previously reported from Minnesota and new to the interior of North America.

13. **Evernia furfuracea** (L.) MANN.

On trees, rare, sterile. Gunflint, July 2, 1897, no. 397. Misquah hills, July 3, 1897, no. 434. Tofte (Carlton peak), July 10, 1897, no. 573.

Not previously reported from Minnesota.

14. **Evernia prunastri** (L.) ACH.

On trees, common. Only seen fertile once. Grand Portage island, June 22, 1897, no. 81. Gunflint, June 30, 1897, no. 267. Misquah hills, July 3, 1897, no. 428. Tofte (Carlton peak), July 10, 1897, no. 554. Tofte, July 10, 1897, no. 635. Beaver Bay, July 14, 1897, no. 717. Two Harbors, July 17, 1897, no. 789. Snowbank lake area, July 20, 1897, no. 841. Ely, July 28, 1897, no. 1002.

15. **Usnea barbata** (L.) FR. var. **florida** FR.

On trees, common or abundant but sterile. Grand Portage island, June 17, 1897, no. 8. Misquah hills, July 3, 1897, no. 420. Tofte (Carlton peak), July 10, 1897, nos. 557 and 607. Beaver Bay, July 14, 1897, no. 722. Snowbank lake area, July 14, 1897, No. 814.

The last has the minute and numerous fibrils of var. *hirta* Fr., but it is not sorediate; while the forms given below under that variety are sorediate, but the fibrils are seldom minute.

16. **Usnea barbata** (L.) FR. var. **hirta** FR.

On trees, common or abundant but sterile. Grand Portage island, June 16, 1897, no. 9. Gunflint, July 1, 1897, no. 356. Misquah hills, July 5, 1897, no. 477. Tofte (Carlton peak), July 10, 1897, nos. 562 and 569. Tofte, July 12, 1897, no.

649. Beaver Bay, July 13, 1897, no. 671. Snowbank lake area, July 19, 1897, nos. 806 and 851. Ely, July 28, 1897, no. 1001.

17. **Usnea barbata** (L.) FR. var. **ceratina** SCHAER.

On trees, common or abundant but sterile. Gunflint, June 30, 1897, no. 263. Misquah hills, July 3, 1897, no. 423. Tofte, (Carlton peak), July 10, 1897, no. 558. Beaver Bay, July 13, 1897, nos. 665 and 672. Snowbank lake area, July 19, 1897, no. 807. Ely, July 28, 1897, no. 993.

Not previously reported from Minnesota.

18. **Usnea barbata** (L.) FR. var. **dasypoga** FR.

On trees, common. Rose lake, June 28, 1897, no. 213.

19. **Usnea barbata** (L.) FR. var. **plicata** FR.

On trees, common. Snowbank lake area, July 19, 1897, no. 805. Ely, July 28, 1897, no. 994.

20. **Usnea trichodea** ACH.

On trees, common. Grand Portage island, June 23, 1897, no. 157. English portage, June 26, 1897, no. 190. Rose lake, June 28, 1897, no. 212. Gunflint, July 2, 1897, no. 381. Misquah Hills, July 3, 1897, no. 432, and July 5, 1897, no. 544. Tofte (Carlton peak), July 10, 1897, no. 547. Tofte, July 12, 1897, no. 659. Beaver Bay, July 13, 1897, no. 667. Two Harbors, July 17, 1897, no. 793.

Not previously reported from Minnesota.

21. **Usnea longissima** ACH.

On trees, common along lake Superior and possibly in Misquah hills. Sterile. Grand Portage island, June 18, 1897, no. 19. Misquah hills, July 3, 1897, no. 422. Tofte, July 12, 1897, no. 649. Beaver Bay, July 13, 1897, no. 649a. Two Harbors, July 17, 1897, no. 787. Snowbank lake area, July 20, 1897, no. 850.

Specimens were collected at Grand Portage island five feet long. The plant breaks with its own weight and hangs abundantly over branches unattached.

Not previously reported from Minnesota.

22. **Usnea cavernosa** TUCK.

On trees, common. Grand Portage island, June 17, 1897, nos. 6 and 18.

23. **Alectoria jubata** (L.) TUCK.

On trees abundant on Grand Portage island, infrequent to common elsewhere. Sterile. Grand Portage island, June 18, 1897, no. 17. Gunflint, July 1, 1897, no. 354. Tofte, July 12, 1897, no. 658. Beaver Bay, July 13, 1897, no. 680. Snowbank lake area, July 20, 1897, no. 837. Ely, July 28, 1897, no. 996.

24. **Alectoria jubata** (L.) TUCK. var. **chalybeiformis** ACH.

On trees and old wood, frequent or common throughout. Sterile. High bluff at south end of South Fowl lake, June 26, 1897, no. 194. Gunflint, June 30, 1897, no. 258, and July 1, 1897, no. 316. Misquah hills, July 5, 1897, no. 514. Beaver Bay, July 15, 1897, no. 786. Snowbank lake area, July 19, 1897, no. 815, and July 20, 1897, no. 842. Ely, July 28, 1897, no. 998.

25. **Alectoria jubata** (L.) TUCK. var. **implexa** FR.

On trees, infrequent. Sterile. Misquah hills, July 3, 1897, no. 421. Beaver Bay, July 14, 1897, no. 731.

Not previously reported from Minnesota.

26. **Theloschistes polycarpus** (EHRH.) TUCK.

On trees, infrequent or rare west of Gunflint, elsewhere frequent or common. Grand Portage island, June 18, 1897, no. 20. Gunflint, July 2, 1897, no. 393. Misquah hills, July 5, 1897, nos. 452 and 487. Beaver Bay, July 13, 1897, nos. 678 and 686. Ely, July 28, 1897, no. 985.

27. **Theloschistes lychneus** (NYL.) TUCK.

On rocks, rare. Grand Portage island, June 23, 1897, no. 147. Snowbank lake area, July 19, 1897, no. 830.

28. **Parmelia perlata** (L.) ACH.

On rocks and rarely on trees, rare to infrequent except at Gunflint, where the species seemed to be common. Sterile. Grand Portage, June 24, 1897, no. 169. Portage between South Fowl lake and Pigeon river, June 26, 1897, no. 205. Gunflint, June 7, 1897, no. 368. Misquah hills, July 5, 1897, no. 543. Beaver Bay, July 14, 1897, no. 725. Snowbank lake area, July 24, 1897, no. 925.

29. **Parmelia perforata** (JACQ.) ACH.

On trees, common. Sterile. Tofte (Carlton peak), July 10, 1897, no. 572.

A puzzling plant with sorediate margined lobes and otherwise resembling the last. However, the margins of the lobes are quite strongly ciliate, and the lower surface of the thallus interruptedly so; possibly might be referred to *P. perlata* (L.) ACH. var. *ciliata*. DC. Thallus rather thinner than my herbarium specimens of *P. perforata*.

30. **Parmelia perforata** (JACQ.) ACH. var. **hypotropa** NYL.
On rocks, rare. Grand Portage, June 23, 1897, no. 116.
Not previously reported from Minnesota.

31. **Parmelia crinita** ACH.
On rocks and once collected on trees, rare or infrequent. Sterile. Grand Portage, June 23, 1897, no. 114. Gunflint, July 1, 1897, nos. 361 and 362. Tofte, July 10, 1897, no. 627. The plant differs from my Iowa and Ohio specimens in that it is strongly ciliate on the upper surface of the thallus among the branchlets and granules.

32. **Parmelia tiliacea** (HOFFM.) FLOERK.
On trees, rare or infrequent. Gunflint, July 2, 1897, no. 407a. Tofte (Carlton peak), July 10, 1897, no. 620. Beaver Bay, July 14, 1897, no. 724a. Ely, July 28, 1897, no. 1018.
Really more frequent along boundary at west. Was frequently noted in Snowbank lake area and failure to get specimens was an oversight.

33. **Parmelia tiliacea** (HOFFM.) FLOERK. var. **sublævigata** NYL.
On trees, rare. Snowbank lake area, July 23, 1897, no. 896.
Not previously reported from Minnesota.

34. **Parmelia borreri** TURN. var. **rudecta** TUCK.
On rocks and trees, rare or infrequent, except common in the Snowbank lake area. All sterile except no. 744 on rocks. Grand Portage, June 24, 1897, no. 188. Gunflint, July 1, 1897, no. 369. Misquah hills, July 3, 1897, no. 431. Tofte (Carlton peak) July 10, 1897, no. 612. Palisades, July 15, 1897, nos. 744 and 762. Snowbank lake area, July 30, 1897, no. 839. Ely, July 28, 1897, no. 983.

35. **Parmelia saxatilis** (L.) FR.
On trees and rarely on rocks. Abundant or common and frequently fruited. Grand Portage island, June 17, 1897, no. 7, and June 21, 1897, no. 57. Misquah hills, July 3, 1897, no.

406. Beaver Bay, July 14, 1897, no. 741. Snowbank lake area, July 21, 1897, no. 873.

36. **Parmelia saxatilis** (L.) Fr. var. **sulcata** Nyl.

On trees, probably common. Grand Portage island, June 17, 1897, no. 7a. Gunflint, June 30, 1897, no. 240.

Not previously reported from Minnesota.

37. **Parmelia physodes** (L.) Ach.

On trees and rocks, common. Gunflint, July 1, 1897, no. 383. Snowbank lake area, July 2, 1897, no. 883.

Doubtless occurring over the whole region studied, but taken for *P. saxatilis* (L.) Fr. modified by some peculiarity of substratum.

38. **Parmelia encausta** (Sm.) Nyl.

On trees, common. Grand Portage island, June 6, 1897, no. 143. Tofte (Carlton peak), July 10, 1897, no. 565.

Not previously reported from Minnesota and new to the interior of North America.

39. **Parmelia olivacea** (L.) Ach.

On trees, common. Grand Portage island, June 18, 1897, no. 11. Grand Portage, June 23, 1897, no. 100. Gunflint, June 30, 1897, no. 260, and July 2, 1897, no. 395. Tofte (Carlton peak), July 10, 1897, nos. 585 and 591. Beaver Bay, July 13, 1897, no. 712. Snowbank lake area, July 20, 1897, no. 848. Ely, July 28, 1897, no. 1004.

40. **Parmelia olivacea** (L.) Ach. var. **prolixa** Ach.

On rocks, common or frequent. High bluff at south end of South Fowl lake, June 26, 1897, no. 197. Gunflint, June 30, 1897, no. 290. Misquah hills, July 5, 1897, no. 491. Tofte (Carlton peak), July 10, 1897, no. 574. Beaver Bay, July 13, 1897, no. 703. Palisades, July 15, 1897, no. 742a. Snowbank lake area, July 20, 1897, no. 832.

Not previously reported from Minnesota and new to the interior of North America.

41. **Parmelia caperata** (L.) Ach.

On trees and rocks, common. Grand Portage island, June 23, 1897, no. 107. Gunflint, June 30, 1897, no. 254a. Misquah hills, July 3, 1897, no. 403. Tofte (Carlton peak), July 10, 1897, no 608. Beaver Bay, July 14, 1897, no. 728. Palisades, July 15, 1897, no. 768. Snowbank lake area, July 19, 1897, no. 804 and July 24, 1897, no. 916.

More commonly fruited than farther south and especially well fruited in the Snowbank lake area.

42. **Parmelia conspersa** (EHRH.) ACH.

On rocks, abundant or common. Grand Portage island, June 23, 1897, no. 103. Gunflint, June 30, 1897, no. 289. Misquah hills, July 5, 1897, no. 506. Tofte (Carlton peak), July 10, 1897, no. 621. Palisades, July 15, 1897, no. 755. Snowbank lake area, July 27, 1897, no. 967.

43. **Parmelia centrifuga** (L.) ACH.

On rocks, rare and sterile. Misquah hills, July 5, 1897, no. 496a.

Not previously reported from Minnesota and new to the interior of the United States.

44. **Physcia speciosa** (WULF. ACH.) NYL.

On rocks and more rarely on old wood or trees, infrequent or frequent. Grand Portage island, June 19, 1897, no. 27. Gunflint, June 30, 1897, no. 270 and July 1, 1897, nos. 342 and 348. Misquah hills, July 3, 1897, no. 438, and July 5, 1897, no. 489. Tofte (Carlton peak), July 10, 1897, nos. 571 and 601. Snowbank lake area, July 24, 1897, no. 911. Nos. 348, 438 and 489 fruited.

45. **Physcia ciliaris** (L.) DC.

On rocks or high bluffs, rare. Grand Portage, June 24, 1897, no. 180. Bluffs at south end of South Fowl lake, June 26, 1897, no. 200. Palisades, July 15, 1897, no. 774.

Not previously reported from Minnesota.

46. **Physcia aquila** (ACH.) NYL.

On trees, rare. Two Harbors, July 17, 1897, no. 791.

The only distinct specimen noted and not found farther north.

Not previously reported from Minnesota.

47. **Physcia pulverulenta** (SCHREB.) NYL.

On rocks infrequent or rare, and not often fruited. Grand Portage island, June 23, 1897, nos. 145 and 145a. Grand Portage, June 23, 1897, no. 173. Gunflint, July 2, 1897, no. 374. Snowbank lake area, July 26, 1897, no. 964.

A very variable plant. No. 145a is the typical form with respect to the upper surface of the thallus, being lighter colored than the others and pruinose. Like the others it is usually dark colored below. No. 173 yielded spores of the usual size measuring $\frac{35-42}{18-23}$ mic. and much constricted in the middle. No. 374 gave spores only $\frac{24-35}{9-12}$ mic. and scarcely constricted.

48. **Physcia pulverulenta** (SCHREB.) NYL. var. **leucoleiptes** TUCK.

On rocks and trees, probably rare. Sterile. Grand Portage island, June 23, 1897, no. 119. Misquah hills, July 5, 1897, no. 496. Snowbank lake area, July 27, 1897, no. 966. Thallus black below.

Not previously reported from Minnesota.

49. **Physcia stellaris** (L.) TUCK.

On trees and rocks, frequent or infrequent. Grand Portage island, June 23, 1897, nos. 105 and 142. Gunflint, June 30, 1897, no. 283a, and July 2, 1897, no. 394. Misquah hills, July 5, 1897, no. 460. Tofte (Carlton peak), July 10, 1897, no. 570. Beaver Bay, July 13, 1897, no. 700. Two Harbors, July 17, 1897, no. 801. Ely, July 28, 1897, no. 1012.

Occasionally the tree forms show dark fibrils and even dark thallus below so that the rock growing variety, below, could only be distinguished certainly by the crenulate border of the apothecia. The plant is much more variable than farther south in Minnesota and Iowa. No. 570 yielded apothecia that were somewhat ciliate below, but the plant is white below and otherwise like the present plant rather than *P. obscura* (Ehr.) Nyl.

50. **Physcia stellaris** (L) TUCK. var. **apiola** NYL.

On rocks, frequent or infrequent. Grand Portage island, June 21, 1897, no. 108. Gunflint, June 30, 1897, no. 284. Misquah hills, July 5, 1897, no. 469. Tofte, July 12, 1897, nos. 640a and 641. Beaver Bay, July 13, 1897, no. 704. Snowbank lake area, July 26, 1897, no. 953.

51. **Physcia tribacia** (ACH.) TUCK.

On rocks, rare and sterile. Grand Portage, June 23, 1897, no. 92. Misquah hills, July 5, 1897, no. 449. Snowbank lake area, July 20, 1897, no. 847.

52. **Physcia hispida** (SCHREB. FR.) TUCK.

On trees, locally infrequent and poorly fruited. Grand Portage island, June 21, 1897, no. 63.

53. **Physcia cæsia** (HOFFM.) NYL.

On rocks, frequent locally. Sterile. Gunflint, June 30, 1897, nos. 282 and 292.

54. **Physcia obscura** (EHRH.) NYL.

On rocks and trees, rare. Grand Portage island, June 23, 1897, no. 145b. Grand Portage, June 24, 1897, no. 172. Tofte, July 12, 1897, no. 642.

No. 145b yielded spores a little large, $\frac{19-33}{9-13}$ mic., and otherwise looks somewhat like *P. pulverulenta* (Schreb.) Nyl., but is black below. Apothecia have hispid borders, and the thallus is much smaller than that of any plants referred to the latter.

55. **Physcia adglutinata** (FLOERK.) NYL.

On trees, rare. Grand Portage, June 23, 1897, nos. 82a and 91a.

56. **Pyxine sorediata** FR.

On rocks and trees, rare but widely distributed. Collected in fruit three times. Gunflint, July 1, 1897, no. 364, and July 2, 1897, no. 385. Misquah hills, July 3, 1897, no. 437. Tofte, July 10, 1897, no. 633. Palisades, July 15, 1897, no. 746. Two Harbors, July 7, 1897, no. 790. Snowbank lake area, July 24, 1897, no. 912.

57. **Umbilicaria muhlenbergii** (ACH.) TUCK.

On rocks, common or abundant. Grand Portage (Mt. Josephine), June 21, 1897, no. 53. Gunflint, June 30, 1897, nos. 245 and 246. Misquah hills, July 5, 1897, no. 537. Tofte (Carlton peak), July 10, 1897, no. 602. Palisades, July 15, 1897, no. 771. Snowbank lake area, July 24, 1897, no. 938.

58. **Umbilicaria vellea** (L.) NYL.

On rocks, common or frequent. Grand Portage (Mt. Josephine), June 21, 1897, no. 57, and June 24, 1897, no. 178. Gunflint, July 1, 1897, no. 367. Misquah hills, July 3, 1897, no. 430, and July 5, 1897, no. 538. Palisades, July 15, 1897, no. 766. Snowbank lake area, July 24, 1897, no. 931.

59. **Umbilicaria dillenii** TUCK.

On rocks, common. Grand Portage, June 24, 1897, no. 170. Gunflint, July 1, 1897, no. 370. Misquah hills, July 3, 1897, no. 429, and July 5, 1897, no. 445. Tofte (Carlton peak), July

10, 1897, no. 599. Palisades, July 15, 1897, no. 775. Snowbank lake area, July 24, 1897, no. 937.

60. **Umbilicaria pustulata** (L.) HOFFM. var. **papulosa** TUCK.

On rocks, rare to frequent. Spores reaching 100 mic. in length. Gunflint, July 1, 1897, no. 371. Misquah hills, July 3, 1897, no. 542. Palisades, July 15, 1897, no. 756. Snowbank lake area, July 24, 1897, no. 932.

61. **Umbilicaria hyperborea** HOFFM.

On rocks, rare, Grand Portage (Mt. Josephine), June 23, 1897, no. 104.

Not previously reported from Minnesota and new to the interior within the United States.

62. **Sticta amplissima** (SCOP.) MASS.

On trees or rocks, rare or infrequent. Grand Portage, June 23, 1897, no. 115. Tofte (Carlton peak), July 10, 1897, no. 609. Beaver Bay, July 14, 1897, no. 720. Two Harbors, July 17, 1897, no. 802. Ely, July 28, 1897, no. 981.

63. **Sticta pulmonaria** (L.) ACH.

On trees or rocks, common or frequent. Grand Portage island, June 19, 1897, no. 23. Rose lake, June 28, 1897, no. 225. Gunflint, July 1, 1897, no. 365. Misquah hills, July 3, 1897, no. 443. Tofte (Carlton peak), July 10, 1897, no. 396. Beaver Bay, July 14, 1897, no. 724. Two Harbors, July 17, 1897, no. 795. Snowbank lake area, July 19, 1897, no. 808. Ely, July 28, 1897, no. 984.

64. **Sticta limbata** (SM.) ACH.

On trees, very rare. Tofte, July 10, 1897, no. 626. Only two plants collected with thallus also much like that of the European *Sticta fuliginosa*. Spores brown, two-celled, constricted, $\frac{19\text{–}23}{8\text{–}9}$ mic.

Not previously reported from Minnesota and only once from North America. (Oregon, by J. W. Eckfeldt.)

65. **Sticta crocata** (L.) ACH.

On trees and rocks, rare. Tofte (Carlton peak), July 10, 1897, no 597. Beaver Bay, July 13, 1897, no. 685. Snowbank lake area, July 24, 1897, no. 940.

Not previously reported from Minnesota and new to the interior within the United States.

66. **Sticta scorbiculata** (Scop.) Ach.

Mossy rocks and trees, rare except at Grand Portage where frequent. Grand Portage, June 24, 1897, no. 176. Tofte, July 10, 1897, no. 629.

Not previously reported from Minnesota and new to the interior of North America.

67. **Nephroma tomentosum** (Hoffm.) Koerb.

On rocks and trees, frequent. Grand Portage island, June 19, 1897, no. 26. Misquah hills, July 5, 1897, no. 541. Tofte, July 10, 1897, no. 634. Snowbank lake area, July 19, 1897, no. 803.

Not previously reported from Minnesota and new to the interior of North America.

68. **Nephroma helveticum** Ach.

On rocks and occasionally on trees and earth, frequent. Grand Portage island, June 23, 1897, no. 133. Gunflint June, 29, 1897, no. 235, and June 30, 1897, no. 250. Misquah hills, July 5, 1897, no. 540. Beaver Bay, July 14, 1897, no. 740. Tofte (Carlton peak), July 10, 1897, no. 605. Snowbank lake area, July 24, 1897, no. 921, and July 26, 1897, no. 961. Ely, July, 28, 1897, no. 1005.

69. **Nephroma lævigatum** Ach.

On trees, rare. Misquah hills, July 5, 1897, no. 426. Two Harbors, July 17, 1897, no. 799.

Not previously reported from Minnesota.

70. **Nephroma lævigatum** Ach. var. **parile** Nyl.

On rocks, locally common. Grand Portage, June 23, 1897, no. 113.

Not previously reported from Minnesota.

71. **Peltigera venosa** (L.) Hoffm.

On earth and mossy rocks, rare, spores reaching 60 mic. in length and occasionally five-celled. Grand Portage, June 23, 1897, no. 150. Portage at south end of South Fowl lake, June 26, 1897, no. 207.

72. **Peltigera aphthosa** (L.) Hoffm.

On earth or rocks, common or frequent. Grand Portage Island, June 24, 1897, no. 177. Gunflint, June 30, 1897, no. 248. Misquah hills, July 5, 1897, no. 526. Palisades, July 15, 1897, no. 770. Snowbank lake area, July 19, 1897, no. 829.

73. **Peltigera horizontalis** (L.) HOFFM.

On earth, frequent or common. Grand Portage island, June 19, 1897, no. 30 and June 23, 1897, no. 121. Gunflint, June 30, 1897, no. 247, and July 1, 1897, nos. 338 and 360. Misquah hills, July 3, 1897, no. 441. Tofte, July 12, 1897, nos. 630 and 631. Beaver Bay, July 14, 1897, no. 723. Palisades, July 15, 1897, no. 761. Snowbank lake area, July 24, 1897, nos. 917 and 918. Part of the plants placed here agree somewhat with those reported elsewhere for Iowa and Minnesota as *P. pulverulenta* (Tayl.) Nyl., but though the sterile forms previously seen differ considerably from the fertile ones herein reported perhaps all must eventually be placed here. The sterile forms, occasionally light colored below, are crisped and broken probably from unfavorable conditions which prevented their fruiting.

Not previously reported from Minnesota.

74. **Peltigera polydactyla** (NECK.) HOFFM.

On earth, common. Spores reaching 110 mic. Grand Portage island, June 23, 1897, nos. 140 and 144. Gunflint, July 1, 1897, no. 336. Misquah hills, July 5, 1897, no. 536. Beaver Bay, July 14, 1897, no 726. Snowbank lake area, July 24, 1897, no. 929, and July 27, 1897, no. 971.

75. **Peltigera canina** (L.) HOFFM. var. **spuria** ACH.

On earth, frequent or common. Grand Portage island, June 19, 1897, no. 29. Grand Portage (Mt. Josephine), June 21, 1897, no. 54. Gunflint, July 1, 1897, no. 323. Beaver Bay, July 13, 1897, no. 663. Palisades, July 13, 1897, no. 760. Snowbank lake area, July 24, 1897, no. 943.

76. **Peltigera canina** (L.) HOFFM. var **sorediata** SCHAER.

On earth, frequent. Grand Portage (Mt. Josephine), June 23, 1897 no. 118a. Gunflint, July 1, 1897, no. 343. Misquah hills, July 5, 1897, no. 535. Tofte (Carlton peak), July 10, 1897, no. 589. Beaver Bay, July 13, 1897, no. 693. Snowbank lake area, July 24, 1897, no. 902. Ely, July 28, 1897, no. 976.

77. **Solorina saccata** (L.) ACH.

On earth, rare. Grand Portage island, June 24, 1897, no. 179. Not previously reported from Minnesota and new to the interior of North America.

78. **Pannaria languinosa** (ACH.) KOERB.

On rocks, common. Grand Portage island, June 17, 1897, no. 1. South Fowl lake, June 26, 1897, no. 195. Gunflint, June 30, 1897, no. 272. Misquah hills, July 3, 1897, no. 435, and July 5, 1897, no. 457. Tofte (Carlton peak), July 10, 1897, no. 561a. Beaver Bay, July 13, 1897, no. 691. Snowbank lake area, July 19, 1897, no. 824. Nos. 195 and 457 showing the bright sulphur-colored plant common in Europe and only noted in North America by the present writer in the second paper of this series.

79. **Pannaria microphylla** (Sw.) Delis.

On rocks, frequent on Grand Portage island, June 19, 1897, no. 22. Gunflint, July 1, 1897, no. 330. Beaver Bay, July 13, 1897, no. 684. Ely, July 28, 1897, no. 987.

80. **Pannaria lepidiota** Th. Fr.

On rocks and wood, infrequent. Grand Portage, June 24, 1897, no. 175. Gunflint, July 2, 1897, no. 372. Misquah hills, July 5, 1897, nos. 463 and 479. Tofte (Carlton peak), July 10, 1897, no. 582. Snowbank lake area, July 24, 1897, no. 908.

Not previously reported from Minnesota.

81. **Pannaria flabellosa** Tuck.

On rocks, rare. Grand Portage island, June 23, 1897, no. 128. Sterile, but having the narrow linear lobed thallus and blue-black hypothallus. The thallus does not show the expanded and striated lobes at circumference.

Not previously reported from Minnesota and new west of New England.

82. **Pannaria nigra** (Huds.) Nyl.

On rocks, rare. Gunflint, July 1, 1897, no. 347.

83. **Ephebe pubescens** Fr.

On rocks, rare, sterile. Palisades, July 13, 1897, no. 745. Snowbank lake area, July 24, 1897, no. 901.

Not previously reported from Minnesota and new to the interior of North America.

84. **Ephebe solida** Born. (?)

On rocks, rare and sterile. Misquah hills, July 5, 1897, no. 488. Beaver Bay, July 13, 1897, no. 683. Snowbank lake area, July 20, 1897, no. 849.

A short form growing in small dense tufts.

85. **Collema pycnocarpum** Nyl.

On trees, rare. Snowbank lake area, July 27, 1897, nos. 968 and 974.

86. **Collema flaccidum** Ach. (?)

On high rocks, rare. Misquah hills, July 5, 1897, no. 495. Sterile, but with the thallus corresponding with tree forms farther south, except that the plant is larger.

87. **Collema nigrescens** (Huds.) Ach.

On trees, especially *Populus*, common or frequent. Grand Portage, June 19, 1897, no. 36, and June 23, 1897, no. 101. Rose lake, June 28, 1897, no. 221. Gunflint, July 30, 1897, no. 266. Misquah hills, July 5, 1897, no. 483. Beaver Bay, July 15, 1897, no. 783. Snowbank lake area, July 19, 1897, no. 822, and July 21, 1879, no. 874. Ely, July 28, 1897, no. 1014.

88. **Collema furvum** (Ach.) Nyl?

On wet rocks, frequent. Grand Portage island, June 23, 1897, no. 156. Tofte, July 12, 1897, no. 646. Not typical.

Not previously reported from Minnesota.

89. **Leptogium lacerum** (Sw.) Fr.

On rocks, rare and sterile. Snowbank lake area, July 21, 1897, no. 867.

90. **Leptogium lacerum** (Sw.) Fr. var. **pulvinatum** Moug. and Nestl.

On rocks, rare. Snowbank lake area, July 29, 1897, no. 965.

Not previously reported from Minnesota.

91. **Leptogium tremelloides** (L.) Fr.

On rocks and rarely on trees. Widely distributed, but usually rare locally. Portage between South Fowl lake and Pigeon river, June 26, 1897, no. 208. Gunflint, July 1, 1897, nos. 349 and 358. Misquah hills, July 3, 1897, no. 424. Beaver Bay, July 15, 1897, no. 781. Snowbank lake area, July 20, 1897, no. 843, July 26, 1897, no. 962, and July 27, 1897, no. 974a. Ely, July 28, 1897, nos. 977 and 1008.

92. **Leptogium myochroum** (Ehrh., Schaer.) Tuck.

On trees and rocks, frequent. Grand Portage island, June 19, 1897, no. 24. Gunflint, July 1, 1897, no. 341. Tofte (Carlton peak), July 10, 1897, no. 598. Snowbank lake area July 19, 1897, no. 820.

Not previously reported from Minnesota.

93. **Leptogium myochroum** (EHRH., SCHAER.) TUCK. var. **tomentosum** SCHAER.

On trees, rare. Tofte (Carlton peak), July 10, 1897, no. 559. Not previously reported from Minnesota.

94. **Placodium elegans** (LINK.) DC.

On rocks, common. Grand Portage, June 21, 1897, no. 69. Grand Portage island, June 23, 1897, nos. 93 and 98. Gunflint, June 30, 1897, no. 294, and July 1, 1897, no. 328. Misquah hills, July 5, 1897, no. 444. Palisades, July 15, 1897, no. 747. Snowbank lake area, July 22, 1897, no. 887, no. 444, looking toward the next in having orange-red apothecia.

95. **Placodium murorum** (HOFFM.) DC.

On rocks, rare. Misquah hills, July 5, 1897, no. 450. Not previously reported from Minnesota.

96. **Placodium murorum** (HOFFM.) DC. var. **miniatum** TUCK.

On rocks, rare. Sterile. Grand Portage, June 23, 1897, no. 88. Not previously reported from Minnesota.

97. **Placodium cinnabarinum** (ACH.) ANZ.

On rocks, common at the one locality. Gunflint, July 2, no. 378.

98. **Placodium citrinum** (HOFFM.) LEIGHT.

On rocks, infrequent. No. 68 well fruited but with thallus nearly obsolete in some specimens. Grand Portage island, June 21, 1897, no. 68. Grand Portage, June 23, 1897, no. 117. Misquah hills, July 5, 1897, no. 461.

99. **Placodium aurantiacum** (LIGHTF.) NAEG. and HEPP.

On rocks, rare at first locality, frequent at second. Grand Portage island, June 23, 1897, no. 127. Gunflint, June 30, 1897. nos. 296 and 298, and July 2, 1897, no. 389. Beaver Bay, July 13, 1897, no. 661. No. 296 with a white thallus and otherwise not typical, but I can place it nowhere else.

100. **Placodium cerinum** (HEDW.) NAEG. and HEPP.

On trees, frequent. Grand Portage, June 23, 1897, no. 84. Gunflint, June 30, 1897, no. 253, and July 2, 1897, no. 392. Beaver Bay, July 13, 1897, no. 669.

101. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **pyracea** NYL.

On old wood, common locally. Beaver Bay, July 13, 1897, no. 682.

102. **Placodium vitellinum** (EHRH.) NAEG. and HEPP.

On old wood, frequent. Beaver Bay, July 13, 1897, no. 660. Spores simple or two-celled and reaching 30 in each ascus.

103. **Placodium vitellinum** (EHRH.) NAEG. and HEPP. var. **aurellum** ACH.

On rocks, common at Gunflint, rare elsewhere. Grand Portage island, June 24, 1897, no. 163. Gunflint, June 30, 1897, no. 279, and July 1, 1897, no. 329. Tofte (Carleton peak), July 10, 1897, no. 618. Snowbank lake area, July 24, 1897, no. 903. Spores reaching 20 in asci.

104. **Lecanora rubina** (VILL.) ACH.

On rocks, common or frequent. Grand Portage (Mt. Josephine), June 19, 1897, no. 47. Grand Portage island, June 21, 1897, no. 73. Gunflint, June 30, 1897, no. 265. Misquah hills, July 5, 1897, no. 486. Beaver Bay, July 13, 1897, no. 705. Snowbank lake area, July 26, 1897, no. 954.

105. **Lecanora rubina** (VILL.) ACH. var. **heteromorpha** ACH.

On rocks, frequent locally. Grand Portage (Mt. Josephine), June 19, 1897, no. 47a. Gunflint, July 1, 1897, no. 326. Palisades, July 15, 1897, no. 748.

Not previously reported from Minnesota.

106. **Lecanora muralis** (SCHREB.) SCHAER. var. **saxicola** SCHAER.

On rocks, common or frequent. Grand Portage island, June 21, 1897, no. 75. Rose lake, June 29, 1897, no. 224. Misquah hills, July 5, 1897, no. 513. Tofte, July 12, 1897, no. 643.

107. **Lecanora muralis** (SCHREB.) SCHAER. var. **diffracta** FR.

On rocks, rare. Grand Portage (Mt. Josephine), June 19, 1897, no. 46.

Not previously reported from Minnesota.

108. **Lecanora pallida** (SCHREB.) SCHAER.

On trees, infrequent. Gunflint, July 1, 1897, no. 337.

Not previously reported from Minnesota.

109. **Lecanora frustulosa** (DICKS.) MASS.

On rocks, frequent. Grand Portage, June 21, 1897, no. 78, and June 23, 1897, no. 153. Gunflint, July 2, 1897, no. 376. Beaver Bay, July, 13, 1897, no. 706.

Not previously reported from Minnesota and new to the interior of North America.

110. **Lecanora sordida** (PERS.) TH. FR.

Rocks, common at the last two locations which were high bluffs. Grand Portage, June 24, 1897, no. 185. South Fowl lake, June 26, 1897, no. 198. Misquah hills, July 5, 1897, nos. 465 and 505.

Not previously reported from Minnesota and new to the interior of North America.

111. **Lecanora subfusca** (L.) ACH.

On trees and rocks, common on the former. Grand Portage, June 23, 1897, no. 131. South end of South Fowl lake, June 26, 1897, no. 202. Misquah hills, July 5, 1897, no. 500. Gunflint, June 30, 1897, no. 274, and July 1, 1897, no. 305. Tofte (Carlton peak), July 10, 1897, nos. 588 and 595. Beaver Bay, July 15, 1897, no. 780. Snowbank lake area, July 19, 1897, no. 825, and July 21, 1897, no. 855.

112. **Lecanora subfusca** (L.) ACH. var. **hypnorum** SCHAER.

Among moss on a cedar tree, rare. Misquah hills, July 5, 1897, no. 494a. Not previously reported from Minnesota.

113. **Lecanora subfusca** (L.) ACH. var. **coilocarpa** Ach.

On trees and rocks, frequent. Grand Portage island, June 21, 1897, no. 67. Gunflint, June 30, 1897, no. 301, and July 1, 1897, no. 339. Misquah hills, July 5, 1897, no. 481. Beaver Bay, July 13, 1897, no. 698.

114. **Lecanora varia** (EHRH.) NYL.

On rocks, rare or infrequent and some specimens perhaps approaching var. *polytropa* Nyl. Grand Portage, June 19, 1897, no. 41. Gunflint, July 1, 1897, no. 307, and July 2, 1897, no. 380.

115. **Lecanora varia** (EHRH.) NYL. var. **sæpincola** FR.

On wood, common at first locality. Beaver Bay, July 14, 1897, no. 742. Snowbank lake area, July 22, 1897, no. 889. Not previously reported from Minnesota.

116. **Lecanora varia** (EHRH.) NYL. var. **symmicta** ACH.

On old wood, rare. Grand Portage island, June 18, 1897, no. 12. Gunflint, July 2, 1897, no. 400. Tofte (Carlton peak), July 10, 1897, no. 580.

117. **Lecanora hageni** ACH.

On rocks, rare. Gunflint, July 1, 1897, no. 357.

118. **Lecanora hageni** ACH. var. **sambuci** (PERS.) TUCK.

On trees common locally. Grand Portage island, June 19, 1897, no. 25. Misquah hills, July 5, 1897, no. 501. Tofte (Carlton peak), July 10, 1897, no. 575.

A puzzling plant with exciple commonly entire or excluded and looking quite as much like forms of *L. subfusca* (L.) Ach. or *L. varia.* (Ehrh.) Nyl. Spores reaching sixteen in asci.

Not previously reported from Minnesota and new to the interior of North America.

119. **Lecanora elatina** Ach.

On trees, rare. Tofte, July 10, 1897, no. 638.

Not previously reported from Minnesota and new to the interior of North America.

120. **Lecanora pallescens** (L.) Schaer.

On trees, infrequent or rare, but widely distributed. Misquah hills, July 3, 1897, no. 412, and July 5, 1897, no. 494. Tofte (Carlton peak), July 10, 1897, no. 592. Beaver Bay, July 13, 1897, no. 674. Two Harbors, July 17, 1897, no. 798. Snowbank lake area, July 21, 1897, no. 864, and July 27, 1897, no. 973.

Not previously reported from Minnesota.

121. **Lecanora tartarea** (L.) Ach.

On rocks, rare. Ely, July 28, 1897, no. 988.

Not previously reported from Minnesota.

122. **Lecanora cinerea** (L.) Sommerf.

On rocks, common or abundant. The thallus varying in color from ash-color to a dull black. Grand Portage (Mt. Josephine), June 19, 1897, no. 39. Grand Portage island, June 21, 1897, no. 74. Gunflint, June 30, 1897, nos. 285, 293a, 295 and 300. Misquah hills, July 5, 1897, nos. 458, 468 and 493a. Tofte (Carlton peak), July 10, 1897, nos. 615 and 622. Palisades, July 15, 1897, no. 752. Beaver Bay, July 15, 1897, no. 778. Snowbank lake area, July 20, 1897, no. 833. Ely, July 28, 1897, no. 990.

123. **Lecanora cinerea** (L.) Sommerf. var. **lævata** Fr.

On rocks, rare. Grand Portage, June 23, 1897, no. 94. Gunflint, June 30, 1897, no. 286. Misquah hills, July 5, 1897, no. 471. Snowbank lake area, July 20, 1897, no. 836.

124. **Lecanora cinerea** (L.) Sommerf. var. **gibbosa** Nyl.

On rocks, rather rare. Grand Portage island, June 23, 1897, no. 79. Gunflint, July 1, 1897, no. 309a. Misquah hills, July 5, 1897, no. 472.

125. **Lecanora calcarea** (L.) SOMMERF. (?)

On rocks, rare. Thallus almost obsolete and spores only $\frac{10-14}{5-7}$ mic. Beaver Bay, July 13, 1897, no. 707.

Not previously reported from Minnesota.

126. **Lecanora calcarea** (L.) SOMMERF. var. **contorta** FR.

On rocks, rare. Grand Portage island, June 23, 1897, no. 155.

Not previously reported from Minnesota.

127. **Lecanora fuscata** (SCHRAD.) TH. FR.

On rocks, frequent. Grand Portage (Mt. Josephine), June 19, 1897, no. 44a. Grand Portage, June 21, 1897, no. 71. Gunflint, July 1, 1897, no. 331.

128. **Lecanora fuscata** (SCHRAD.) TH. FR. var. **rufescens** TH. FR.

On rocks, frequent at second locality. Misquah hills, July 5, 1897, no. 446. Beaver Bay, July 14, 1897, no. 718, and July 15, 1897, no. 777.

Not previously reported from Minnesota.

129. **Rinodina oreina** (ACH.) MASS.

On rocks, rare, preferring high perpendicular rocks or larger masses of talus. No. 750 is an unusually coarse form, but must be referred here. South end of South Fowl lake, June 26, 1897, no. 203. Misquah hills, July 5, 1897, no. 518. Palisades, July 15, 1897, nos. 750 and 753. Snowbank lake area July 20, 1897, no. 854.

130. **Rinodina ascociscana** TUCK.

On trees, rare. Gunflint, July 1, 1897, no. 340. Tofte (Carlton peak), July 10, 1897, no. 594.

Not previously reported from Minnesota.

131. **Rinodina sophodes** (ACH.) NYL.

Abundant on drift pebbles at Beaver Bay, infrequent on wood elsewhere. Grand Portage, June 23, 1897, no. 95. Tofte, July 12, 1897, no. 651. Beaver Bay, July 13, 1897, no. 702. Snowbank lake area, July 20, 1897, no. 853.

132. **Rinodina sophodes** (ACH.) NYL. var. **confragosa** NYL.

On wood, rare. Spores 25 to 34 mic. in length. Snowbank lake area, July 21, 1897, no. 875.

Not previously reported from Minnesota.

133. **Pertusaria velata** (TURN.) NYL.

On trees, infrequent. Portage, between Rose and Rove lakes, June 27, 1897, no. 210a. Tofte (Carlton peak), July 10, 1897, no. 577. Ely, July 28, 1897, no. 1017.

134. **Pertusaria multipuncta** (TURN.) NYL.

On trees, frequent at second locality. Tofte (Carlton peak), July 10, 1897, no. 611. Snowbank lake area, July 28, 1897, no. 900.

135. **Pertusaria multipunctata** (TURN.) NYL. var. **lævigata** TURN. and BORR.

On trees, probably frequent. Grand Portage, June 23, 1897, no. 158. Rose lake, June 28, 1897, no. 217a. Gunflint, July 2, 1897, no. 389a. Misquah hills, July 5, 1897, no. 478.

Not previously reported from Minnesota and new to North America.

136. **Pertusaria communis** DC.

On trees, nearly always cedars, common or frequent. Portage, between Rose and Rove lakes, June 27, 1897, no. 210. Rose lake, June 28, 1897, no. 217. Gunflint, July 1, 1897, no. 336, Misquah hills, July 7, 1897, nos. 453 and 499. Beaver Bay, July 13, 1897, no. 664, and July 15, 1897, no. 782. Snowbank lake area, July 21, 1897, nos. 870 and 888.

137. **Pertusaria** sp.

On trees. Spores nearly like the above in the few apothecia not transformed into soredia. Thallus lighter colored at circumference with frequent two or three dark lines near circumference. Misquah hills, July 3, 1897, no. 410. Beaver Bay, July 15, 1897, no. 688. Snowbank lake area, July 19, 1897, no. 826.

138. **Pertusaria leioplaca** (ACH.) SCHAER.

On trees, widely distributed but seldom common in any locality. Grand Portage, June 23, 1897, no. 91. Portage between North Fowl lake and Moose lake, June 26, 1897, no. 192. Rose lake, June 28, 1897, no. 218. Gunflint, June 30, 1897, no. 275, and July 2, 1897, no. 399. Misquah hills, July 5, 1897, no. 491a. Beaver Bay, July 15, 1897, no. 784. Ely, July 28, 1897, no. 1010. Varying greatly according to substratum. On young trees with smooth bark the thallus is thin and smooth and the ostioles frequently indistinct. On older trees with rough bark the thallus is thicker and broken, and the apothecia are falsely lecanoroid. The last feature is due no doubt to great age of these plants which began growth when the trees were young. The extremes appear macroscopically like distinct species.

Not previously reported from Minnesota.

139. **Pertusaria pustulata** (ACH.) NYL.

On trees, infrequent. Rose lake, June 28, 1897, no. 228. Gunflint, July 1, 1897, no. 310. Misquah hills, July 3, 1897, no. 418.

140. **Pertusaria glomerata** (ACH.) SCHAER.

On rocks, very rare. Misquah hills, July 5, 1897, no. 490.

Not previously reported from Minnesota and new to the interior of North America.

141. **Gyalecta fagicola** (HEPP.) TUCK.

On trees, rare. Snowbank lake area, July 22, 1897, no. 880.

Not previously reported from Minnesota and new to west of of New England.

142. **Urceolaria scruposa** (L.) NYL.

On rocks, rare or infrequent, but widely distributed and no. 126 with thallus approaching var. *gypsacea* Nyl. Grand Portage island, June 25, 1897, no. 126. Gunflint, June 30, 1897, no. 302. Misquah hills, July 5, 1897, no. 473. Beaver Bay, July 13, 1897, no. 701. Snowbank lake area, July 23, 1897, no. 899. Ely, July 28, 1897, no. 978.

143. **Stereocaulon coralloides** FR.

On rocks, frequent. Tofte (Carlton peak), July 10, 1897. no. 549.

Not previously reported from Minnesota and new to the interior of North America.

144. **Stereocaulon paschale** (L.) FR.

On earth among rocks, common. Grand Portage (Mt. Josephine), June 19, 1897, no. 49. Grand Portage island, June 21, 1897, no. 50. Gunflint, June 30, 1897, no. 233. Misquah hills, July 5, 1897, no. 482. Beaver Bay, July 13, 1897, no. 689. Palisades, July 15, 1897, no. 758. Snowbank lake area, July 24, 1897, no. 927. No. 49 seems to approach the above. Also no. 50 has the stout podetia of *S. tomentosum* (Fr.) Th. Fr. and is somewhat tomentose. Yet it appears nearer herb. specimens of the above.

145. **Cladonia symphycarpa** Fr. var. **epiphylla** (Ach.) Nyl.

In crevices in rocks, rare. Habitat unusual but thallus too large for *C. cæspiticia* (Pers.) Fl. Gunflint, July 1, 1897, no. 363.

Not previously reported from Minnesota.

146. **Cladonia mitrula** Tuck.

On earth, rare. Beaver Bay, July 15, 1897, no. 694.

147. **Cladonia cariosa** (Ach.) Spreng.

On earth, probably frequent. Grand Portage island, June 23, 1897, nos. 120 and 146. Gunflint, July 1, 1897, no. 324. Misquah hills, July 5, 1897, nos. 509 and 533. Tofte (Carlton peak), July 10, 1897, no. 606. Beaver Bay, July 14, 1897, nos. 737 and 739.

The forms listed here seem to me to be partly intermediate between this and the last having the habit of this, but some are rather small with the squamules usually small. *C. mitrula* Tuck. is the common form in southern Minnesota, but the better development of this region runs into the present species. Of the specimens here listed no. 146 is the best representative of the species and no. 120 the poorest. Some of the smaller approaches *C. symphycarpa* Fr., which is itself a doubtful species.

148. **Cladonia decorticata** Floerk.

On earth, rare. Beaver Bay, July 14, 1897, no. 738. Not previously reported from Minnesota and new to west of New England.

149. **Cladonia pyxidata** (L.) Fr.

On earth, common. Grand Portage island, June 19, 1897, no. 32. Gunflint, July 1, 1897, nos. 333 and 352. Misquah hills, July 5, 1897, no. 534. Tofte (Carlton peak), July 10, 1897, nos. 567 and 568. Beaver Bay, July 14, 1897, no. 735. Snowbank lake area, July 21, 1897, no. 868, and July 27, 1897, no. 972.

150. **Cladonia fimbriata** (L.) Fr.

On earth, rare. Gunflint, June 30, 1897, no. 259.

Not previously reported from Minnesota.

151. **Cladonia fimbriata** (L.) Fr. var. **tubæformis** Fr.

On dead wood and earth, common. Grand Portage island, June 23, 1897, no. 129. Gunflint, June 30, 1897, no. 268. Misquah hills, July 3, 1897, no. 439. Tofte (Carlton peak), July 10, 1897, no. 561. Snowbank lake area, July 24, 1897, no. 930.

152. **Cladonia fimbriata** (L.) Fr. var. **radiata** Fr.

On earth and old wood, frequent. Grand Portage island, June 19, 1897, no. 33 and June 24, 1897, no. 162. Gunflint, June 30, 1897, no. 234. Snowbank lake area, July 20, 1897, no. 840.

Not previously reported from Minnesota.

153. **Cladonia gracilis** (L.) Nyl.

On earth, common or abundant and extremely variable. Grand Portage island, June 19, 1897, no. 35. Gunflint, July 1, 1897, nos. 325, 344 and 345. Misquah hills, July 5, 1897, nos. 508 and 522. Tofte (Carlton peak), July 10, 1897, nos. 550, 564 and 604. Beaver Bay, July 14, 1897, no. 734. Snowbank lake area, July 21, 1897, no 876 and July 24, 1897, nos. 922 and 923.

154. **Cladonia gracilis** (L.) Nyl. var. **verticillata** Fr.

On earth, rare, Grand Portage island, June 19, 1897, nos. 35b and 35d. Tofte (Carlton peak), July 10, 1897, no. 625.

155. **Cladonia gracilis** (L.) Nyl. var. **symphycarpia** Tuck.

On earth, infrequent, possibly as near *C. degenerans* Floerk. Grand Portage island, June 19, 1897, no. 35a.

Not previously reported from Minnesota.

156. **Cladonia gracilis** (L.) Nyl. var. **cervicornis** Floerk.

On earth, rare. Gunflint, June 30, 1897, no. 231.

Not previously reported from Minnesota.

157. **Cladonia gracilis** (L.) Nyl. var. **hybrida** Schaer.

On earth, common. Grand Portage island, June 19, 1897, no. 35c. Gunflint, July 1, 1897, no. 346. Misquah hills, July 3, 1897, no. 433. Snowbank lake area, July 19, 1897, no. 821, and July 24, 1897, no. 905.

158. **Cladonia turgida** (Ehrh.) Hoffm.

On earth, common at Gunflint. Gunflint, June 30, 1897, nos. 241 and 252. Snowbank lake area, July 24, 1897, no. 928.

Not previously reported from Minnesota.

159. **Cladonia turgida** (Ehrh.) Hoffm. var. **conspicua** (Schaer.) Nyl.

On earth, frequent. Rose lake, June 28, 1897, no. 237. Misquah hills, July 3, 1897, no. 425, and July 5, 1897, no. 525. Tofte, (Carlton peak), July 10, 1897, nos. 603 and 637.

Not previously reported from Minnesota.

160. **Cladonia squamosa** HOFFM.

On earth, common or abundant. Grand Portage island, June 24, 1897, no. 165. Gunflint, June 30, 1897, no. 232, and July 1, 1897, no. 350, and July 2, 1897, no. 384. Misquah hills, July 5, 1897, no. 529. Tofte, July 12, 1897, nos. 628 and 632. Beaver Bay, July 14, 1897, no. 719. Above Palisades, July 15, 1897, no. 772. Snowbank lake area, July 24, 1897, nos. 913, 919 and 924. Ely, July 28, 1897, no. 995.

161. **Cladonia squamosa** HOFFM. var. **phyllocoma** RABENH.

On earth, frequent. Grand Portage island, June 23, 1897, no. 141. Misquah hills, July 5, 1897, no. 459. Snowbank lake area, July 24, 1897, nos. 939 and 942.

Not previously reported from Minnesota and new to North America.

162. **Cladonia cornuta** (L.) FR.

On earth, rare. Grand Portage island, June 24, 1897, no. 159. Misquah hills, July 5, 1897, no. 511.

Not previously reported from Minnesota.

163. **Cladonia delicata** (EHRH.) FL.

On old wood, rare. Beaver Bay, July 13, 1897, no. 692.

164. **Cladonia cæspiticia** (PERS.) FL.

On old wood, rare. Tofte (Carlton peak), July 10, 1897, no. 586.

165. **Cladonia furcata** (HUDS.) FR.

On earth, frequent. Gunflint, June 30, 1897, nos. 236 and 237. Misquah hills, July 5, 1897, no. 524. Above Palisades, July 15, 1897, no, 767. Snowbank lake area, July 24, 1897, no. 914.

166. **Cladonia furcata** (HUDS.) FR. var. **crispata** FL.

On earth, common locally. Grand Portage, June 24, 1897, no. 168. Gunflint, June 30, 1897, no. 249. Palisades, July 15, 1897, no. 757.

167. **Cladonia rangiferina** (L.) HOFFM.

On earth, abundant or common. Grand Portage island, June 17, 1897, no. 2, and June 23, 1897, 135. Grand Portage (Mt. Josephine), June 19, 1897, no. 48. Gunflint, June 30, 1897, no. 244. Misquah hills, July 5, 1897, no. 521. Tofte, (Carlton peak), July 10, 1897, no. 548. Beaver Bay, July 14, 1897, no. 732. Palisades, July 15, 1897, no. 759. Snowbank lake area, July 24, 1897, no. 926.

168. **Cladonia rangiferina** (L.) HOFFM. var. **sylvatica** L.

On earth, frequent. Misquah hills, July 5, 1897, no. 531. Tofte (Carlton peak), July 10, 1897, no. 553. Snowbank lake area, July 24, 1897, nos. 915 and 936.

169. **Cladonia rangiferina** (L.) HOFFM. var. **alpestris** L.

On earth, common locally. Grand Portage, June 24, 1897, no. 171. Gunflint, July 1, 1897, no. 351. Above Palisades, July 15, 1897, no. 773.

170. **Cladonia amaurocræa** (FL.) SCHAER.

On earth and rocks, common or frequent. Grand Portage (Mt. Josephine), June 21, 1897, no. 52. Grand Portage island, June 24, 1897, no. 164. Gunflint, June 30, 1897, no. 243. Misquah hills, July, 5, 1897, nos. 530 and 532. Tofte (Carlton peak), July, 10, 1897, no. 552. Palisades, July 15, 1897, no. 769. Snowbank lake area, July 24, 1897, nos. 935 and 941.

Not previously reported from Minnesota.

171. **Cladonia uncialis** (L.) FR.

On earth, frequent or common. Grand Portage (Mt. Josephine), June 21, 1897, no. 55. Grand Portage, June 24, 1897, no. 167. Gunflint, June 30, 1897, no. 239. Misquah hills, July 5, 1897, no. 475. Misquah hills, July 5, 1897, no. 528. Tofte (Carlton peak), July 10, 1897, no. 551. Beaver Bay, July 14, 1897, no. 727. Palisades, July 15, 1897, no. 764. Snowbank lake area, July 24, 1897, no. 933.

172. **Cladonia cornucopioides** (L.) FR.

On earth, rare but widely distributed. Grand Portage, June 24, 1897, no. 166. Gunflint, July 30, 1897, no. 238. Misquah hills, July 5, 1897, nos. 497 and 527. Tofte (Carlton peak), July 10, 1897, no. 563. Above Palisades, July 15, 1897, no. 754.

173. **Cladonia deformis** (L.) HOFFM.

On earth, rare. Grand Portage island, June 23, 1897, no. 151.

Not previously reported from Minnesota and new to the interior of North America.

174. **Cladonia digitata** (L.) HOFFM.

On an old stump, rare. Tofte, July 12, 1897, no. 655.

Not previously reported from Minnesota and new to the interior of North America.

175. **Cladonia macilenta** (Ehrh.) Hoffm.

On old wood and earth, rare. Misquah hills, July 5, 1897, no. 510. Above Palisades, July 15, 1897, no. 776.

176. **Cladonia cristatella** Tuck.

On earth and old wood, abundant. Grand Portage island, June 18, 1897, no. 31. Gunflint, July 1, 1897, nos. 322 and 332. Misquah hills, July 3, 1897, no. 417. Tofte (Carlton peak), July 10, 1897, no. 610. Beaver Bay, July 14, 1897, no. 736. Snowbank lake area, July 19, 1897, no. 827.

177. **Bæomyces byssoides** (L.) Schaer.

On rocks, rare. Grand Portage island, June 21, 1897, no. 109.

Not previously reported from Minnesota, and new to the interior of North America.

178. **Bæomyces æruginosus** (Scop.) DC.

On rotton wood, common. Grand Portage island, June 18, 1897, no. 16. Gunflint, July 1, 1897, no. 309. Misquah hills, July 3, 1897, no. 404. Tofte, July 12, 1897, no. 639. Beaver Bay, July 14, 1897, no. 721. Snowbank lake area, July 19, 1897, no. 823.

Not previously reported from Minnesota, and new to the interior of North America.

179. **Biatora rufonigra** Tuck.

On rocks, frequent. Grand Portage (Mt. Josephine), June 19, 1897, no. 37. Grand Portage island, June 21, 1897, no. 64. South Fowl lake, June 26, 1897, no. 193. Misquah hills, July 5, 1897, no. 456. Snowbank lake area, July 21, 1897, no. 859.

180. **Biatora coarctata** (Sm., Nyl.) Tuck.

On rocks, rare. Beaver Bay, July 13, 1897, no. 709.

Not previously reported from Minnesota.

181. **Biatora viridescens** (Schrad.) Fr.

On old wood, common locally. Misquah hills, July 3, 1897, no. 414.

Snowbank lake area, July 20, 1897, no. 846.

Not previously reported from Minnesota, and new to the interior of North America.

182. **Biatora vernalis** (L.) Fr.

On old wood, mosses and trees, frequent. Grand Portage island, June 21, 1897, no. 61, and June 23, 1897, no. 149. Gunflint, June 30, 1897, no. 262.

Not previously reported from Minnesota.

183. **Biatora sanguineoatra** (FR.) TUCK.

On earth common. Grand Portage island, June 19, 1897, no. 21 and 28. Grand Portage, June 24, 1897, no. 181. Gunflint, June 30, 1897, no. 269, and July 1, 1897, no. 359. Misquah hills, July 5, 1897, no. 413. Tofte (Carlton peak), July 10, 1897, no. 578. Snowbank lake area, July 22, 1897, no. 884.

Not previously reported from Minnesota.

184. **Biatora turgidula** (FR.) NYL.

On old wood, rare. Grand Portage island, June 18, 1897, no. 14.

Not previously reported from Minnesota.

185. **Biatora leucophæa** (FLOERK).

On rocks, infrequent. Grand Portage, June 23, 1897, no. 139, and June 24, 1897, no. 187. Gunflint, July 1, 1897, no. 306.

Not previously reported from Minnesota.

186. **Biatora leucophæa** FLOERK var. **griseoatra** KOERB.

On rocks, rare. Grand Portage, June 24, 1897, no. 186.

Not previously reported from Minnesota and new south of Arctic America.

187. **Biatora uliginosa** (SCHRAD.) FR.

On earth, abundant near Disappointment lake. Beaver Bay, July 13, 1897, no. 708. Snowbank lake area, July 24, 1897, no. 944. Ely, July 28, 1897, no. 997.

Not previously reported from Minnesota.

188. **Biatora sphæroides** (DICKS.) TUCK.

On old wood, rare. Snowbank lake area, July 24, 1897, no. 944a.

Not previously reported from Minnesota.

189. **Biatora glauconigrans** TUCK.

On trees, rare. Gunflint, July 1, 1897, no. 398.

Not previously reported from Minnesota and new west of New England.

190. **Biatora arthropurpurea** (MASS.) HEPP.

On trees, rare. Grand Portage island, June 21, 1897, no. 56. Snowbank lake area, July 22, 1897, no. 811. Ely, July 28, 1897, no. 1007.

191. **Biatora oxyspora** (Tul.) Nyl.

On *Parmelia colpodes*, rare. Misquah hills, July 3, 1897, no. 416.

Not previously reported from Minnesota and new to the interior of North America.

192. **Biatora lucida** (Ach.) Fr.

On damp rocks, rare. Grand Portage, June 23, 1887, no. 183.

Not previously reported from Minnesota and new to the interior of North America.

193. **Biatora myriocarpoides** (Nyl.) Tuck.

On old wood, frequent locally. Beaver Bay, July 13, 1897, no. 673. Apothecia larger than usual.

194. **Biatora flavidolivens** Tuck.

On old wood, frequent locally. Rose lake, June 28, 1897, no. 214. Misquah hills, July 5, 1897, no. 504.

Not previously reported from Minnesota and new west of New England.

195. **Biatora hypnophila** (Turn.) Tuck.

On trees, rare. Gunflint, June 30, 1897, no. 273. Snowbank lake area, July 26, 1897, no. 956.

196. **Biatora nægelii** Hepp.

On old wood, rare. Beaver Bay, July 13, 1897, no. 715. Not previously reported from Minnesota and new west of New England.

197. **Biatora rubella** (Ehrh.) Rabenh.

On trees, rare or infrequent. Tofte (Carlton peak), July 10, 1897, no. 546. Beaver Bay, July 13, 1897, no. 640. Snowbank lake area, July 19, 1897, no. 812, July 21, 1897, no. 872, and July 24, 1897, no. 906. Ely, July 28, 1897, no. 1021.

198. **Biatora fuscorubella** (Hoffm.) Tuck.

On trees, infrequent. Snowbank lake area, July 17, 1897, no. 816, and July 21, 1897, no. 861.

199. **Biatora schweinitzii** Fr.

On cedars, rare. Misquah hills, July 5, 1897, no. 493.

Not previously reported from Minnesota.

200. **Biatora incompta** (Borr.) Hepp.

On trees, probably common locally. Rose lake, June 28, 1897, no. 222. Gunflint, July 1, 1897, no. 335.

Not previously reported from Minnesota.

201. **Biatora muscorum** (Sw.) Tuck.

On trees with moss, rare. Snowbank lake area, July 26, 1897, no. 963.

202. **Heterothecium sanguinarium** (L.) Flot.

On old wood and occasionally on trees or rocks, common except in last region. Gunflint, July 1, 1897, nos. 318 and 319. Misquah hills, July 3, 1897, nos. 409 and 415, and July 5, 1897, nos. 492a and 498. Tofte (Carlton peak), July 10, 1897, no. 581. Beaver Bay, July 15, 1897, no. 695. Two Harbors, July 17, 1897, no. 796. Snowbank lake area, July 19, 1897, no. 810.

Not previously reported from Minnesota and new to the interior of North America.

203. **Heterothecium sanguinarium** (L.) Flot. var. **affine** Tuck.

On wood, rare. Rose lake, June 28, 1897, no. 222a.

Not previously reported from Minnesota and new to the interior of North America.

204. **Lecidea lactea** Fl.

On rocks along lake Superior, common especially north. Grand Portage island, June 21, 1897, no. 76, and June 23, 1897, no. 136. Grand Portage, June 23, 1897, no. 182. Tofte, July 12, 1897, no. 652. Palisades, July 15, 1897, no. 751.

Not previously reported from Minnesota and new to the interior of North America.

205. **Lecidea crustulata** Ach.

On rocks, rare. Grand Portage island, June 23, 1897, no. 137.

Not previously reported from Minnesota and known elsewhere in North America only from Labrador by Eckfeldt and Arnold.

206. **Lecidea lapicida** Fr.

On rocks, probably common locally. Misquah hills, July 5, 1897, no. 448.

Not previously reported from Minnesota and new to the interior of North America.

207. **Lecidea lapicida** Fr. var. **oxydata** Fr.

On rocks, rare. Grand Portage, June 24, 1897, no. 174.

Not previously reported from Minnesota and new to the interior of North America.

208. **Lecidea speirea** Nyl.

On rocks along lake shore, rare. Grand Portage island, June 23, 1897, no. 110.

Not previously reported from Minnesota.

209. **Lecidea albocærulescens** (Wulf.) Schaer.

On rocks, rare. Misquah hills, July 5, 1897, no. 484.

210. **Lecidea platycarpa** Ach.

On rocks, rare. Misquah hills, July 5, 1897, no. 474.

Not previously reported from Minnesota.

211. **Lecidea enteroleuca** Fr.

On trees and rocks, common. Grand Portage island, June 21, 1897, nos. 59b and 60, and June 23, 1897, no. 111. Grand Portage, June 23, 1897, no. 148. English Portage, June 26, 1897, no. 191. Misquah hills, July 5, 1897, no. 492. Beaver Bay, July 13, 1897, no. 700. Snowbank lake area, July 24, 1897, no. 909.

212. **Lecidea enteroleuca** Fr. var. **achrista** Sommerf.

On trees, infrequent. Grand Portage island, June 21, 1897, no. 59a. Grand Portage, June 23, 1897, no. 97.

Not previously reported from Minnesota.

213. **Lecidea melancheima** Tuck.

On old wood, rare. Gunflint, July 2, 1897, no. 390. Misquah hills, July 5, 1897, no. 454. Snowbank lake area, July 20, 1897, no. 835.

Not previously reported from Minnesota.

214. **Lecidea cyrtidia** Tuck.

On pebbles, rare, thallus reduced and hence the black hypothallus prominent. Snowbank lake area, July 27, 1897, no. 969.

Not previously reported from Minnesota.

215. **Lecidea acclinis** Flot.

On cedars, rare. Gunflint, July 1, 1897, no. 353.

Not previously reported from Minnesota.

216. **Buellia alboatra** (Hoffm.) Th. Fr.

On rocks, rare.

Grand Portage, June 23, 1897, no. 99.

Not previously reported from Minnesota.

217. **Buellia parasema** (Ach.) Th. Fr.

On trees, common. Ely specimen having spores reaching $\frac{18-30}{7-11}$ mic. Grand Portage island, June 16, 1897, no. 4, and

June 21, 1897, no. 65. South Fowl lake, June 26, 1897, no. 196. Gunflint, July 1, 1897, nos. 311 and 312. Misquah hills, July 5, 1897, no. 480. Beaver Bay, July 15, 1897, no. 676. Snowbank lake area, July 19, 1897, nos. 811a, 813 and 817. Ely, July 28, 1897, no. 989a.

218. **Buellia parasema** (ACH.) TH. FR. var. **triphragmia** NYL.

On trees, infrequent. Gunflint, June 30, 1897, nos. 255 and 278. Tofte, July 10, 1897, no. 613.

Not previously reported from Minnesota.

219. **Buellia dialyta** (NYL.) TUCK.

On pines, rare. Two Harbors, July 17, 1897, no. 792.

Not previously reported from Minnesota, and new to the interior of North America.

220. **Buellia myriocarpa** (DC.) MUDD.

On old wood, abundant locally. Beaver Bay, July 14, 1897, no. 716a.

221. **Buellia myriocarpa** (DC.) MUDD. var. **polyspora** WILLEY.

On trees, rare. Ely, July 28, 1897, no. 1011.

222. **Buellia petræa** (FLOT., KOERB.) TUCK.

On rocks, common or abundant. Grand Portage island, June 17, 1897, no. 5. Gunflint, June 30, 1897, nos. 281, 283 and 291. Misquah hills, July 5, 1897, no. 470. Beaver Bay, July 15, 1897, no. 779. Ely, July 28, 1897, no. 989.

223. **Buellia petræa** (FLOT., KOERB.) TUCK. var. **grandis** FLOERK.

On rocks, rare. Gunflint, June 30, 1897, no. 293, and July 1, 1897, no. 304.

224. **Buellia petræa** (FLOT., KOERB.) TUCK. var. **montagnæi** TUCK.

On rocks, common or abundant. Grand Portage (Mt. Josephine), June 18, 1897, no. 42. Gunflint, July 2, 1897, no. 379. Misquah hills, July 5, 1897, no. 467. Beaver Bay, July 13, 1897, no. 662. Palisades, July 15, 1897, no. 749. Snowbank lake area, July 20, 1897, no. 834.

225. **Buellia geographica** (L.) TUCK.

On rocks, rare and approaching var. *lecanorina* Flœrk Gunflint, June 30, 1897, no. 303. Palisades, July 15, 1897, no. 743.

Not previously reported from Minnesota, and new to the interior of North America.

226. **Buellia parmeliarum** (SOMMERF.) TUCK.

On *Parmelia borreri*, rare. Snowbank lake area, July 22, 1897, no. 885.

Not previously reported from Minnesota.

227. **Opegrapha varia** (PERS.) FR.

On trees, common on cedars except along lake Superior. Gunflint, July 1, 1897, no. 334. Misquah hills, July 5, 1897, no. 502. Tofte (Carlton peak), July 10, 1897, no. 593. Snowbank lake area, July 21, 1897, no. 857.

228. **Opegrapha varia** (PERS.) TUCK. FR. var. **notha** ACH.

On cedars, locally abundant. Rose lake, June 28, 1897, no. 220.

Not previously reported from Minnesota.

229. **Graphis scripta** (L.) ACH.

On trees, frequent or common. Grand Portage island, June 21, 1897, no. 66. Gunflint, July 1, 1897, nos. 314 and 317. Tofte (Carlton peak), July 10, 1897, no. 576. Beaver Bay, July 15, 1897, no. 716. Snowbank lake area, July 21, 1897, no. 858.

230. **Graphis scripta** (L.) ACH. var. **recta** (HUMB.) NYL.

On birch trees, infrequent. Grand Portage, June 24, 1897, no. 189. Misquah hills, July 3, 1897, no. 405. Tofte, July 12, 1897, no. 650. Snowbank lake area, July 23, 1897, no. 897.

231. **Graphis scripta** (L.) ACH. var. **limitata** ACH.

On trees, very rare. Resembles *G. dendritica* externally as to apothecia. Misquah hills, July 5, 1897, no. 451.

Not previously reported from Minnesota.

232. **Arthonia dispersa** (SCHRAD.) NYL.

On *Acer spicatum*, abundant. Grand Portage, June 23, 1897, no. 86. Tofte (Carlton peak), July 10, 1897, no. 590. Beaver Bay, July 13, 1897, no. 714. Snowbank lake area, July 20, 1897, no. 845. Ely, July 28, 1897, no. 979.

Not previously reported from Minnesota.

233. **Arthonia radiata** (PERS.) TH. FR.

On trees in low places, common. Grand Portage island, June 23, 1897, no. 123. Rose lake, June 28, 1897, no. 219. Gunflint, July 1, 1897, no. 315, and July 2, 1897, no. 388. Tofte (Carlton peak), July 10, 1897, no. 584, Beaver Bay, July 15, 1897, no. 785. Snowbank lake area, July 20, 1897, no. 838. Ely, July 28, 1897, no. 1013.

234. **Arthonia punctiformis** Ach.

On trees, locally common. Gunflint, June 30, 1897, no. 277. Misquah hills, July 3, 1897, no. 407.

235. **Arthonia patellulata** Nyl.

On trees, rare. Gunflint, June 30, 1897, no. 254.

Not previously reported from Minnesota.

236. **Calicium trichiale** Ach.

On trees, common locally. Rose lake, June 28, 1897, no. 230. Beaver Bay, July 15, 1897, no. 696. Snowbank lake area, July 19, 1897, no. 818.

Not previously reported from Minnesota, and new to the interior of North America.

237. **Calicium trichiale** Ach. var. **stemoneum** Nyl.

On pine, common. Ely, July 28, 1897, no. 992.

Not previously reported from Minnesota, and new to the interior of North America.

238. **Calicium brunneolum** Ach.

On decorticated wood, common locally. Two Harbors, July 17, 1897, no. 800. Snowbank lake area, July 12, 1897, no. 860. Ely, July 26, 1897, no. 1000.

Not previously reported from Minnesota, and new to the interior of North America.

239. **Calicium chrysocephalum** (Turn.) Ach.

On trees, frequent. Misquah hills, July 5, 1897, no. 447. Two Harbors, July 17, 1897, no. 788. Snowbank lake area, July 22, 1897, no. 882. Ely, July 28, 1897, no. 1003.

Not previously reported from Minnesota, and new to the interior of North America.

240. **Calicium chrysocephalum** (Turn.) Ach. var. **filare** Sch.

On cedars, rare. Tofte, July 12, 1897, no. 647.

Not previously reported from Minnesota. Variety apparently new to North America.

241. **Calicium parietinum** Ach.

On decorticated wood, common. Grand Portage island, June 17, 1897, no. 3. Gunflint, July 2, 1897, no. 382. Misquah hills, July 3, 1897, no. 408.

Not previously reported from Minnesota.

242. **Calicium quercinum** Pers.

On dead wood, infrequent. Rose lake, June 28, 1897, no. 229. Tofte (Carlton peak), July 10, 1897, no 583.

Not previously reported from Minnesota.

243. **Calicium hyprellum** Ach. var. **viride** Nyl.

On trees, rare. Misquah hills, July 5, 1897, no. 476. Snowbank lake area, July 21, 1897, no. 877, and July 22, 1897, no. 893. Ely, July 28, 1897, no. 1015.

Not previously reported from Minnesota. Variety new to North America. Stipes sometimes very short.

244. **Calicium turbinatum** Pers.

On *Pertusaria communis*, rare. Beaver Bay, July 13, 1897, no. 664a. Snowbank lake area, July 21, 1897, no. 866.

Not previously reported from Minnesota.

245. **Coniocybe pallida** (Pers.) Fr.

On *Fraxinus*, rare. Snowbank lake area, July 19, 1897, no. 831.

Not previously reported from Minnesota.

246. **Endocarpon miniatum** (L.) Schaer.

On rocks, along shore of lake Superior, very rare. Grand Portage island, June 21, 1897, no. 80.

247. **Endocarpon miniatum** (L.) Schaer. var. **complicatum** Schaer.

On rocks, frequently 1000 feet above water level, frequent. Grand Portage (Mt. Josephine), June 19, 1897, no. 38. Grand Portage island, June 23, 1897, no 102. Misquah hills, July 5, 1897, no. 445.

248. **Endocarpon fluviatile** DC.

On rocks frequently inundated, common. Rose lake, June 28, 1897, no. 211. Gunflint, July 1, 1897, no. 327. Misquah hills, July 7, 1897, no. 512. Snowbank lake area, July 21, 1897, no. 878.

249. **Thelocarpon prasinellum** Nyl.

On rocks, rare. Grand Portage (Mt. Josephine), June 22, 1897, no. 90.

The plant agrees here and not with saxicoline species, European or American.

250. **Staurothele umbrina** (Wahl.) Tuck.

Wet rocks, common. Misquah hills, July 5, 1897, nos.

462, 519 and 520. Snowbank lake area, July 26, 1897, no. 957.

Not previously reported from Minnesota.

251. **Staurothele drummondii** TUCK.

On rocks along the shore, frequent locally. Grand Portage island, June 21, 1897, no. 72.

Not previously reported from Minnesota and new to the interior of North America.

252. **Verrucaria nigrescens** PERS.

On rocks, rare. Grand Portage, June 24, 1897, no. 184.

253. **Verrucaria epigæa** (PERS.) ACH.

On earth, rare. Snowbank lake area, July 26, 1897, no. 944.

Not previously reported from Minnesota.

254. **Sagedia oxyspora** (NYL.) TUCK.

On birch, rare. Beaver Bay, July 13, 1897, no. 697.

Not previously reported from Minnesota and new to the interior of North America.

255. **Pyrenula punctiformis** (ACH.) NAEG. var. **fallax** NYL.

On trees, common. Gunflint, June 30, 1897, no. 276. Misquah hills, July 5, 1897, no. 503. Snowbank lake area, July 21, 1897, no. 871, and July 26, 1897, no. 950.

Not previously reported from Minnesota.

256. **Pyrenula leucoplaca** (WALLR.) KRB.

On trees, common to west of region. Between Rose and Rove lakes, June 27, 1897, no. 209. Gunflint, July 2, 1897, no. 391. Misquah hills, July 5, 1897, nos. 499 and 507. Snowbank lake area, July 19, 1897, no. 828, July 20, 1897, no. 852, and July 26, 1897, nos. 955, 958 and 959. Ely, July 28, 1897, nos. 1009 and 1019.

257. **Pyrenula cinerella** (FLOT.) TUCK.

On birch, common. Grand Portage island, June 21, 1897, no. 56.

The only American specimens seen by me which show the spores as large as those of the European plant. Spores measured 12–18 by 6–9 mic. Spore measurements for the species in America are more commonly 12–17 by 5–7 mic., my Iowa specimens giving 12–16 by 6–7 mic., and T. A. William's from Nebraska, 15–17 by 5½–7 mic.

Not previously reported from Minnesota.

258. **Pyrenula cinerella** (Flot.) Tuck. var. **quadriloculata,** *var. nov.*

Spores 12–15 by 5–6½ mic., passing from 2 and occasionally 3-celled to a much more common 4-celled condition. The apothecia somewhat below normal size for the species. *Pyrenula punctiformis* Ach., Naeg. var. *fallax* Nyl., quite commonly occurs with the species and variety, as it does with the latter in the present instance and with the former both in Minnesota and Iowa.

On birch, probably common locally. Grand Portage island, June 24, 1897, no. 85.

XIX. CONTRIBUTIONS TO A KNOWLEDGE OF THE LICHENS OF MINNESOTA.—V. LICHENS OF THE MINNESOTA VALLEY AND SOUTHWESTERN MINNESOTA.

Bruce Fink.

CONSIDERATIONS OF DISTRIBUTION AND HABITAT.

The area considered in this paper was selected with a view to obtaining as complete a knowledge as possible of the lichen flora of the Minnesota river valley and of that of southwestern Minnesota in general.

The upper portion of the valley near Minneapolis would, of course, give a flora essentially like that of Minneapolis and vicinity already studied. Hence, for the month's field work, it was thought best to begin operations at a locality a considerable distance from Minneapolis. As an initial place, Mankato, about 60 miles from Minneapolis, was selected. The location of this city is also advantageous in that it lies nearly midway between the Minneapolis and the northeastern Iowa areas compared carefully in the second paper of this series, thus forming a connecting link between the two areas previously studied. After a careful study of the lichens of the Mankato area both to gain a knowledge of the lichen flora of the region and for the sake of relationships with the areas indicated above, New Ulm was next selected as an area of special interest because of the exposures of Cretaceous sandstone and the most southeastward exposures of quartzite rocks in the valley. At New Ulm only these two rock formations were studied, as time spent on other substrata present would only be repaid for most part by a repetition of the species found upon the same substrata at Mankato, only 30 miles distant. Three days were next spent at Redwood Falls, Morton and North Redwood with a view to securing rare species and noting the southeastern extension of certain species in the valley. From here I proceeded to Granite Falls.

This being the most northwestern area reached in the survey, its lichen flora was studied carefully. The final task was to study the lichen flora of the pipestone and the Sioux quartzite at Pipestone.

A brief statement as to substrata is next in order. About Mankato trees abound, and three kinds of rock—limestone, sandstone and bowlders—are plentiful. I found only the two interesting substrata mentioned above at New Ulm. Trees and bowlders were abundant, but were not studied for the reason already stated. At Redwood Falls, Morton and North Redwood, granite trees and earth were examined for species especially rare or interesting. The great masses of granite, supposed to have been exposed since the close of the glacial age, formed the most interesting substratum at Granite Falls. This is also the most northwestern area in the valley where trees occur in any considerable numbers. The calcareous drift pebbles and calcareous earth proved also very interesting here. The two substrata examined at Pipestone have been mentioned. I need to add only one statement more to make the analysis of substrata complete enough for the present purpose. This is that earth was examined everywhere and furnished much of interest, as will appear later.

The following rare lichens were found only at Redwood Falls, Morton or North Redwood: *Peltigera canina* (L.) Hoffm. var. *spongiosa* Tuck. and *Stereocaulon paschale* (L.) Fr. Also the area including the above places forms the most southeastern known extension of the following lichens in the valley: *Parmelia olivacea* (L.) Ach. var. *prolixa* Ach.; *Pannaria microphylla* (Sw.) Delis; *Omphalaria phyllisca* (Wahl.) Tuck.; *Lecanora frustulosa* (Dicks.) Mass., and *Buellia pullata* Tuck. With this much in hasty review I shall pass to localities more thoroughly studied. However, I may add here better than elsewhere in my paper that *Rinodina oreina* (Ach.) Mass. and *Lecanora xanthophana* Nyl. are here and elsewhere in the valley far more abundant than I have ever found them in other regions.

In attempting a general comparative study of distribution in the valley the places that present questions of greatest interest are the vicinities of Mankato and Granite Falls, where all sorts of substrata were examined. The two areas were about equally well studied, though the former, because of the greater number and less accessibility of rocky substrata, required more time. The former area furnished 151 species and varieties and the latter 124. A brief analysis of the causes of the advantage in favor of the former region can be best made by a consideration of the subjoined table, giving the various substrata for both localities with the number of lichens most commonly found on each.

	Numbers for Mankato.	For Granite Falls.
Trees	60	41
Rocks	55	54
Earth	22	17
Dead wood	14	12

A complete analysis introducing per cents as was made in a former paper is not necessary since general likeness except for trees is apparent in the table. The difference in richness then is due mainly to absence of large areas of trees at Granite Falls. The slight differences in the other three items in the table is doubtless due to difference in moisture, the precipitation being 30.53 inches annually at Mankato for three years for which I could get data and 21.83 inches annually at Granite Falls for five years for which data were obtained. Difference in moisture doubtless also accounts in small measure for the advantage of the Mankato area as to arboreal lichens.

As to rocky substrata favorable to lichen growth little can be definitely given by way of comparison. As to kinds of rocks Mankato has an advantage in having the sandstone which is wanting at Granite Falls, and also in the great masses of limestone which are replaced at Granite Falls only by the calcareous drift pebbles and a few bowlders. Yet these two advantages are probably quite overcome by the great masses of exposed granite at Granite Falls, not replaced at Mankato in any way, since granitic bowlders are equally abundant in both places.

Comparing the Mankato vicinity with Minneapolis and with Fayette, Iowa, two areas compared in a former portion of these studies, we find that it has a much richer lichen flora than the former region which gave only 113 lichen forms and probably nearly as rich as the latter which gave 157 lichens which one could expect to find in a study of limited duration.

Minnesota has now furnished more lichens than any other state in the Mississippi Valley, having 351 species and varieties. Illinois with 249 lichens being next in order. Yet the fact that northeastern Iowa, a portion of a State not so thoroughly surveyed and only having 226 known lichens, has 26 lichens not yet found in Minnesota, shows that the study of Minnesota lichens is by no means yet approximately completed, since a large part of these 26 rare or obscure lichens found already within 50 miles of the state certainly exist within its borders in the southeastern portion, and other unstudied portions of the state may yet be expected to bring additions to the lichen flora in like proportion. A list of these 26 lichens could be added with habitats to aid in their discovery in southeastern Minnesota but an inspection of another paper* will give the names of them.

A study of the table above, giving habitats and number of species for each, by per cents, would give a somewhat larger per cent. of lithophytic lichen species for the two areas considered than a former study exhibited for the Minneapolis and Iowa localities and about the same per cent. as the lake Superior region. I subjoin, arranged according to habitat, a list of the 41 lichens added to the state in this paper. From the list it will be seen that more than half of these species are most common on rocks, and that the great Archean and Algonkian masses exposed throughout the upper valley alone produced one-third of them. For convenience of reference to the above statements I shall now add the table, placing rock species first, and then follow the list with further discussion.

New to Minnesota on Archean or Algonkian rocks.

Ramalina polymorpha (Ach.) Tuck.

Parmelia saxatilis (L.) Fr. var. **panniformis** (Ach.) Schaer.

Pyrenopsis phæococca Tuck.

Pyrenopsis melambola Tuck.

Omphalaria phyllisca (Wahl.) Tuck.

Leptogium pulchellum (Ach.) Nyl.

Lecanora sp.

Lecanora subfusca (L.) Ach. var. **allophana** Ach.

Lecanora cinerea (Pers.) Nyl. var. **cinereoalba** var. nov.

Rinodina sophodes (Ach.) Nyl. var. **tephraspis** Tuck.

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* Fink, B. Review of Lichenological Studies in the Upper Mississippi Valley, with suggestions for future investigations. In list to be published in *Memoirs of the Torrey Botanical Club.*

Rinodina lecanorina MASS.
Urceolaria actinostoma PERS.
Buellia pullata TUCK.

New to Minnesota on limestone.

Omphalaria kansana TUCK.
Omphalaria pulvinata NYL.
Collema plicatile SCHAER.
Collema pustulatum ACH.
Lecanora bookii (FR.) TH. FR.
Rinodina bischoffii (HEPP.) KOERB.
Buellia alboatra (HOFFM.) TH. FR. var. **saxicola** FR.
Staurothele diffractella (NYL.) TUCK.

New to Minnesota on wood.

Placodium ferrugineum (HUDS.) HEPP.
Placodium ferrugineum (HUDS.) HEPP. var. **pollinii** TUCK.
Cladonia cristatella TUCK. var. **paludicola** TUCK.
Biatora flexuosa FR.
Biatora suffusa FR.
Buellia turgescens (NYL.) TUCK.
Opegrapha varia (PERS.) FR. var. **pulicaris** FR.
Arthonia sp.
Endocarpon arboreum SCHWEIN.
Pyrenula gemmata (ACH.) NAEG.
Pyrenula hyalospora NYL.
Pyrenula quinqueseptata (NYL.) TUCK.
Pyrenula glabrata (ACH.) MASS.
Pyrenula megalospora sp. nov.

New to Minnesota on earth.

Heppia despreauxii (MONT.) TUCK.
Heppia polyspora TUCK.
Collema tenax (SW.) ACH.
Biatora decipiens (EHRH.) FR.
Biatora decipiens (EHRH.) FR. var. **dealbata** AUCT.

The list of species new to the state shows a large number of *Pyrenulas*, the genus being unusually well represented in the valley, especially at Mankato. It will also be seen that the gelatinous lichens, the *Collemei*, are especially conspicuous in the genera *Pyrenopsis*, *Omphalaria*, *Collema* and *Leptogium*. This happens because part of the valley is more favorable for their development as to substrata and moisture than other studied portions of the state. The part of the studied portion of the valley most favorable for their development is the Mankato vicinity where most of the gelatinous lichens were found. The whole number of *Collemei* found in the valley is 17. Richness is apparent when we add that only four were found about Minneapolis, 11 in the lake Superior region and that only 16 are known in Iowa.

It may be added that a large proportion of the species added to the state flora are of special interest for various reasons. Thus the *Omphalarias* are not commonly collected; *Lecanora bookii* (Fr.) Th. Fr. is a difficult lichen to detect; the *Pyrenulas* are difficult to distinguish macroscopically and are therefore commonly overlooked; members of the genus *Pyrenopsis* are seldom reported; while *Urceolaria actinostoma* Pers., *Buellia pullata* Tuck. and *Heppia polyspora* Tuck. are very rare lichens. *Rinodina lecanorina* Mass. is reported for the first time from North America, and *Lecanora cervina* (Pers.) Nyl. var. *cinereoalba* var. nov. is interesting because new.

It may be noted in passing that the region shows some of the Arctic or sub-Arctic species found at Taylor's Falls and already discussed in a former paper. These are *Biatora rufonigra* Tuck., two forms of *Buellia petræa* (Flot., Koerb.) Tuck. and an *Ephebe*, though not the species reported from Taylors Falls. As in the Taylors Falls region the *Buellia* is the most common of these species being a crustaceous form well adapted to resist unfavorable conditions. The *Biatora* is next in frequency of occurrence and the *Ephebe*, a fruticulose form, was only seen once. So far as I was able to ascertain by careful search the foliaceous forms, *Umbilicaria* and *Nephroma*, found at Taylors Falls have not succeeded in persisting in the Minnesota valley. This failure of northern forms to persist so successfully may be accounted for perhaps in a very small degree by more southern position of the area now under consideration, but no doubt is due much more to climatic and edaphic factors which have allowed plant migrations to proceed northward more rapidly in the Minnesota valley than farther east in the state since the last retreat of the glaciers. This matter has been touched upon by Professor C. MacMillan.* It is interesting to note that the strictly crustaceous *Buellia* is the only one of the more northern forms found in the state which persists as far south as Pipestone. Indeed, its abundance here and records of occurrence elsewhere well southward in low altitudes since Tuckerman wrote lead to the suspicion that it may not be so strictly sub-Arctic in distribution as I have supposed. It may be added that the *Buellia* is the only one of these northern species persisting in the valley, which was found on bowlders at any considerable distance from the large masses of Archean and Algonkian rocks, which are supposed to have been exposed continuously since the close of the glacial epoch, and that it was only found once in very small quantity on a bowlder remote from these larger masses.

It has been my plan to introduce in each paper of the series some feature regarding distribution which could be especially well illustrated by the area under consideration. In the study of the Minnesota valley and southwestern Minnesota I was able to keep in mind a variety of ecologic factors and to preserve the data necessary for their solution. This I had previously done in part for several areas in Minnesota and Iowa so that in the present paper interesting and instructive comparisons can be made. Leaving other questions, then, thus briefly stated, I shall now pass to a consideration of the lichen formations of the region, causes of their peculiar make-up, and comparisons with similar formations within and outside the area under consideration.

Aside from the purely scientific interest of the analysis to follow, it has a practical bearing, in that knowledge of the relation between ecologic factors and distribution enables the collector to predict in the field about what species of lichens he may expect to find in a spot having a given set of environmental features. In the study species rarely found in the formations have not been considered when there appeared to be doubt as to whether they were collected on their usual substrata, and rarer varieties have been omitted when showing the same habitat as other forms of the species. It will be readily granted that the commoner forms which give character to the flora are the ones which should receive attention in such a study. In

* MacMillan, C., Observations on the Distribution of Plants Along the Shore at Lake of the Woods. Minn. Bot. Stud. 1 : 967. 1897.

the analysis, especially as to amount of illumination and the roughness of ligneous substrata, it will be seen that lines can not be drawn very closely without entailing an amount of minutiæ which would be confusing and therefore unprofitable.

With the above brief statement as to the main purpose of the present paper, I shall begin the consideration of lichen formations with the most distinct ones with which I am acquainted, viz., those of the Sioux quartzite at Pipestone. These formations are distinct because for most part removed from trees from which lichens commonly migrate to rocks nearby, producing tension lines and mixture of formations and because the few young trees found, though large enough to bear the foliaceous lichens which commonly migrate to the rocks, have apparently been isolated from larger areas of trees from the beginning of growth and scarcely bear a lichen of any kind. The rocky substratum is for the most part horizontal and exposed to the sun's rays. In a few places occur perpendicular rock exposures which are more or less shaded by trees, overhanging rocks or north exposure. A few ombrophytic lichens occupy these spots; but they are all strictly lithophytic species, none of them having, for the reason stated above, migrated from trees as we shall find to be the condition in a later analysis of other similar formations. Below I give first the lichen formation of the horizontal exposed rocks and second, that of the more or less shaded and damp rocks. *Lecanoras* predominate in the formations on exposed rocks, which may accordingly be named as follows:

Lecanora formation of the horizontal exposed quartzite.
(Pipestone).

Parmelia olivacea (L.) Ach. var. **prolixa** Ach., C.
Parmelia conspersa (Ehrh.) Ach., C.
Physcia tribacia (Ach.) Tuck., C.
Physcia cæsia (Hoffm.) Nyl.
Placodium elegans (Link.) DC., C.
Placodium vitellinum (Ehrh.) Naeg. and Hepp.
Lecanora rubina (Vill.) Ach., C.
Lecanora rubina (Vill.) Ach. var. **heteromorpha** Ach., C.
Lecanora cinerea (L.) Sommerf., C.
Lecanora xanthophana Nyl., C.

Rinodina oreina (ACH.) MASS., C.

Buellia spuria (SCHAER.) ARN., C.

Buellia pullata TUCK., C.

Buellia petræa (FLOT., KOERB.) TUCK. var. **montagnæi** TUCK., C.

Endocarpon miniatum (L.) SCHAER. var. **complicatum** SCHAER., C.

The formation on shaded rocks may be designated the *Staurothele formation*, after the prevailing genus.

Staurothele formation of shaded or damp quartzite (Pipestone).

Endocarpon miniatum (L.) SCHAER.

Staurothele umbrina (WAHL.) TUCK., C.

Staurothele drummondii TUCK., C.

The lichen formations of the pipestone lying beside the quartzite were studied to ascertain to what extent the difference in chemical composition and hardness of the rocks would influence the distribution of lichens, other ecologic factors being identical. In the above table I have indicated species common to quartzite and pipestone by (C.), and the table shows that only three lichens were detected on the quartzite and not on the pipestone. The following three, all growing in exposed places, were found on the latter and not on the former.

Placodium cinnabarrinum (ACH.) AUZ.

Placodium cerinum (HEDW.) NAEG. and HEPP. var. **sideritis** TUCK.

Lecanora muralis (SCHREB.) SCHAER. var. **saxicola** SCHAER.

It is worthy of note that the differences are specific and that the formations are identical generically. The appearance of a certain plant in a particular set of ecological conditions is too complicated a matter for exact explanation in many instances, and I can offer no explanation as to why the few plants occur on one kind of rock and not on the other. Possibly the specific acid secreted by a particular species acts more readily on one kind of rock than on the other, but more probably the cause is other than this. Nor do I suppose that I have found, here or in other formations to be considered below, all the lichens growing under a particular set of conditions. Yet the common ones which give character to the various formations were doubtless all detected here as elsewhere, and the fact that 15 of 18 were found on each kind of rock demonstrates that difference in composition of rock in this instance has produced little, if any difference in lichen flora. A similar study of lichen formations on large rock areas of greater difference in composition as granite and limestone lying adjacent would be of special interest.

To complete the lichen formations of the area, the earth-lichen formation must be considered. This formation and similar ones elsewhere may be called the *Endocarpon hepaticum formations of exposed earth* from a plant which is found in such formations in all parts of the state except the lake Superior region.

Endocarpon hepaticum formation of exposed earth (Pipestone).

Urceolaria scruposa (L.) Nyl.

Cladonia pyxidata (L.) Fr.

Cladonia fimbriata (L.) Fr.

Cladonia fimbriata (L.) Fr. var. **tubæformis** Fr.

Biatora muscorum (Sw.) Tuck.

Endocarpon hepaticum Ach.

Endocarpon pusillum Hedw. var. **garovaglii** Kph.

The region is a comparatively dry one because of small precipitation of moisture, since the rocks lie high where there is little or no standing water to give moisture and because there are few trees to give shade. The lichen formations are accordingly rather poor in species, as will appear in comparisons to follow an analysis of similar formations.

The rocky surfaces at Granite Falls present a much more complex set of conditions than those just considered, and yet, for my purpose, they may be classified, like the latter, into exposed surfaces, usually horizontal, and shaded surfaces, usually more or less nearly perpendicular. I shall now record these formations in the same order as in the last series; but after each shall compare it with the corresponding formation at Pipestone, giving, as far as possible, the probable cause of differences.

Lecanora formation of exposed (usually horizontal) granite (Granite Falls).

Parmelia olivacea (L.) Ach. var. **prolixa** Ach.

Parmelia conspersa (Ehrh.) Ach.

Physcia stellaris (L.) Tuck. var. **apiola** Nyl., A.

Physcia cæsia (Hoffm.) Nyl.

Placodium elegans (Link.) DC.

Placodium murorum (Hoffm.) DC., A.

Placodium cinnabarrinum (Ach.) Auz.

Placodium cerinum (Hedw.) Naeg. and Hepp. var. **sideritis** Tuck.

Placodium vitellinum (Ehrh.) Naeg. and Hepp.

Lecanora rubina (Vill.) Ach.

Lecanora rubina (Vill.) Ach. var. **heteromorpha** Ach.

Lecanora muralis (Schreb.) Schaer., A.

Lecanora muralis (Schreb.) Schaer. var. **saxicola** Schaer.

Lecanora frustulosa (Dicks.) Mass., A.

Lecanora subfusca (L.) Ach. var. **allophana** Ach., A.

Lecanora subfusca (L.) Ach. var. **coilocarpa** Ach., A.

Lecanora hageni Ach., A.

Lecanora cinerea (L.) Sommerf.

Lecanora calcarea (L.) Sommerf. var. **contorta** Fr., A.

Lecanora xanthophana Nyl.

Lecanora cervina (Pers.) Nyl. var. **cinereoalba** var. nov., A.

Lecanora fuscata (Schrad.) Th. Fr., A.

Rinodina oreina (Ach.) Mass.

Rinodina sophodes (Ach.) Nyl., A.

Rinodina lecanorina Mass., A.

Urceolaria actinostoma Pers., A.

Biatora rufonigra Tuck., A.

Buellia spuria (Schaer.) Arn.

Buellia pullata Tuck.

Buellia petræa (Flot., Koerb.) Tuck.

Endocarpon miniatum (L.) Schaer., var. **complicatum** Schaer.

Comparing this lichen formation with the similar ones of the Sioux quartzite and the pipestone, we find it to contain all lichens found on the two except *Physcia tribacia* (Ach.) Tuck. and to contain fourteen not found on them, which I have marked as additions (A). The absence of the one species from the Granite Falls formation is doubtless an accident in plant distribution whose explanation would be very difficult or impossible to trace; but it is quite remarkable that with this exception all the plants found in the two formations sixty miles away should occur in this lichen formation also, especially since there could have been no rocky connection between the two areas since glacial times. It is not strange that the exposed granite lichen formation at Granite Falls should be a much richer one than the two exposed formations at Pipestone combined; for it is a much larger area, is connected with a limestone lichen formation and an epiphytic, and a number of swamps and ponds furnish moisture along the borders. Indeed the presence of ten of the fourteen additions may be more or less satisfactorily explained. These I shall proceed to consider *seriatim*.

Physcia stellaris (L.) TUCK., var. **apiola** TUCK.—a lithophytic variety of a species common on adjacent trees.

Lecanora frustulosa (DICKS.) MASS.—a northern lichen not extending so far south as Pipestone.

Lecanora subfusca (L.) ACH., var. **alliophana** ACH.—a variety of a species common on trees near by.

Lecanora subfusca (L.) ACH., var. **coilocarpa** ACH.—as the last above.

Lecanora cervina (PERS.) NYL., var. **cinereoalba** var. nov.—has not been seen outside the Minnesota valley.

Lecanora calcarea (L.) SOMMERF., var. **contorta** FR.—a lichen migrating from the limestone near by.

Rinodina sophodes (ACH.) NYL.—found on trees of the region and perhaps migrating from them.

Rinodina lecanorina MASS.—a very rare plant which, therefore, very probably does not exist at Pipestone or was overlooked.

Urceolaria actinostoma PERS.—as the last above.

Biatora rufonigra TUCK.—a northern form not extending so far south as Pipestone.

Though somewhat confusing another similar lichen formation must be introduced here for comparison as follows:

Lecanora formation of exposed quartzite (New Ulm).

Parmelia conspersa (EHRH.) ACH., CTS.

Physcia cæsia (HOFFM.) NYL., CTS.

Placodium cerinum (HEDW.) NAEG. and HEPP. var. **sideritis** TUCK., CT.

Placodium vitellinum (EHRH.) NAEG. and HEPP., CTS.
Lecanora rubina (VILL.) ACH., CTS.
Lecanora rubina (VILL.) ACH. var. **heteromorpha** ACH., CS.
Lecanora subfusca (L.) ACH., S.
Lecanora varia (EHRH.) NYL., AS.
Lecanora cinerea (L.) SOMMERF., CTS.
Lecanora xanthophana NYL., C.
Rinodina oreina (ACH.) MASS., C.
Rinodina sophodes (ACH.) NYL.
Biatora rufonigra TUCK., T.
Biatora myriocarpoides (NYL.) TUCK., A.
Buellia spuria (SCHAER.) ARN., CT.
Buellia petræa (FLOT., KOERB.) TUCK., CTS.
Endocarpon miniatum (L.) SCHAER. var. **complicatum** SCHAER., C.

Comparing the above lichen formation with the similar ones at Pipestone and Granite Falls we find it to contain only two species which are additions to the three at the two places just named. These I have marked (A). It is about as extensive an area as the two at Pipestone combined, has about the same number of lichens as both and has 12 species (marked C) which are common to all the exposed rock lichen formations in the area considered in this paper. In general these 12 species may be regarded as the most constant of the exposed Archean and Algonkian rock lichen formations of southwestern Minnesota. As we multiply areas of comparison and especially as we introduce those at a greater distance the number of common floral elements very naturally decreases. Thus considering the similar formation at Taylors Falls, we find only 8 species (marked T) common to it and all the similar ones previously considered, and passing to the corresponding formation at Gunflint in the lake Superior region, the number found in all these similar formations in widely separated areas of the state is found to be only 6 (marked S). These 6 species may be looked for with considerable certainty wherever such lichen formations are well developed in the state. Other elements will vary according to relation to other adjacent formations, position northward or southward and in some instances eastward or westward in the state and to various ecologic factors which cannot be enumerated fully.

We may now turn to the lichen formation of shaded or damp rocks at Granite Falls. This includes some flat rock surfaces somewhat shaded or simply wet part of the time, as well as the perpendicular shaded surfaces. I shall divide the formation into three parts—species naturally belonging to the rocks, those which have probably migrated from the trees near at hand and those which have probably migrated from the earth. Here and in another formation we have a mixture of elements, hence the following name is proposed:

Mixed formation of shaded (or damp) granite (Granite Falls).

A. PROBABLY NATURALLY BELONGING TO THE ROCKS.

Ramalina polymorpha (ACH.) TUCK.
Ramalina calicaris (L.) FR. var. farinacea SCHAER.
Pannaria microphylla (SW.) DELIS.
Pannaria languinosa (ACH.) KOERB.
Omphalaria phyllisca (WAHL.) TUCK.
Collema furvum (ACH.) NYL.
Leptogium lacerum (SW.) FR.
Endocarpon muriatum (L.) SCHAER.
Staurothele umbrina (WAHL.) TUCK.
Staurothele diffractella (NYL.) TUCK.
Staurothele drummondii TUCK.

B. NEAR TREES AND PROBABLY MIGRATED FROM THEM.

Parmelia cetrata ACH.
Parmelia crinita ACH.
Parmelia borreri TURN.
Parmelia borreri TURN. var. hypomela TUCK.
Parmelia saxatilis (L.) FR.
Parmelia saxatilis (L.) FR. var. sulcata NYL.
Parmelia saxatilis (L.) FR. var. panniformis (ACH.) SCHAER.
Parmelia caperata (L.) ACH.
Physcia speciosa (WULF., ACH.) NYL.
Physcia pulverulenta (SCHREB.) NYL.
Physcia obscura (EHRH.) NYL.
Pyxine sorediata FR.
Leptogium myochroum (EHRH., SCHAER.) TUCK.

Placodium aurantiacum (LIGHTF.) NAEG and HEPP.
Biatora fuscorubella (HOFFM.) TUCK.

C. SPECIES WHICH HAVE PROBABLY MIGRATED FROM EARTH.

Peltigera rufescens (NECK.) HOFFM.
Peltigera canina (L.) HOFFM.

Of the three parts of the formation under consideration only the first can be compared with the similar formation at Pipestone, and we find besides the 3 species of the Pipestone formation, 8 additional forms as a result of greater areas studied, more moist conditions near the Minnesota river, and where abundant ponds and marshes situated near the rocks give moisture, and where trees are numerous in some parts of the area and increase the shade. I must add that presence of the *Ramalinas* here, and their absence from shaded rocks at Pipestone leads to the suspicion that they may have sprung from *Ramalina calicaris* (L.) Fr. of the region, migrating from trees to rocks and acquiring the varietal, and in one instance the specific characters as an adaptation to changed environment. The question is as to whether these lichens are sufficiently plastic to acquire such new characters since trees have grown in the valley in post-glacial time. I can only say that I believe that they may be, and that it is quite as likely that the two *Ramalinas* should be placed in the second division of the formation as in the first.

As to plants of the second portion of the formation, which I have designated as having probably migrated from trees, in some instances they are locally more abundant and luxuriant on the rocks than on trees. Hence a hasty consideration would lead to the conclusion that they have not migrated. But the luxuriant condition obtains on the rocks in *Parmelia borreri* Turn., a lichen seldom seen on rocks elsewhere, and many of these lichens grow on mossy rocks where lichens are commonly large. Also it is to be taken into account that these lichens are those usually found on large trees with rough bark. The larger trees were for most part destroyed years ago by man or fires, and these lichens, formerly common on trees, are preserved on rocks better than on the less permanent trees. Hence some of them are more common now on the rocks than on the trees, which are for most part second growth and not large. The third division, consisting of two *Peltigeras*, scarcely needs any special consideration.

I shall next consider the similar shaded rock formation at New Ulm, which may be divided into those lichens naturally belonging to the rocks and those probably migrating from trees.

Mixed lichen formation of shaded rocks (New Ulm).

A. NATURALLY BELONGING TO THE ROCKS.

Pannaria languinosa (ACH.) KOERB.

Collema flaccidum ACH.

Collema furvum (ACH.) NYL.

B. NEAR TREES AND PROBABLY MIGRATED FROM THEM.

Theloschistes lychneus (NYL.) TUCK., CTS.

Parmelia crinita ACH., CTS.

Parmelia borreri TURN., CTS.

Parmelia saxatilis (L.) FR., CTS.

Parmelia saxatilis (L.) FR. var. **panniformis** (ACH.) SCHAER., C.

Parmelia caperata (L.) ACH., CTS.

Physcia speciosa (WULF. ACH.) NYL., CTS.

Physcia pulverulenta(SCHREB.) NYL., CTS.

Physcia stellaris (L.) TUCK., TS.

Physcia obscura (EHRH.) NYL., CTS.

As to the shaded rock lichen formations of the region surveyed considering only plants naturally belonging to the rocks, there is not a single lichen that is common to all of them. *Pannaria languinosa* (Ach.) Koerb. is the most constant element of such formations, which as a whole might be named for this plant were it not quite as common in shaded limestone formations otherwise quite different from any of those on the rocks under consideration at present. Of the lichens of the shaded rock formation at New Ulm, which have probably migrated from trees, the nine marked common (C), may be taken as the ones most commonly occurring, as they were found also at Granite Falls in the similar formation. Those marked (T) all but one of the nine, occur in the similar formation at Taylors Falls. Other elements vary more with change in various ecologic factors. The similar partial formation was noted at Grand Portage, especially on the island, and adding those lichens (S) of it found in the corresponding ones considered above, subtracts none from the number of common species. Therefore, these eight lichens may be regarded as the elements of that portion of the shaded rock lichen formations which have probably migrated from trees, most widely occurring in such formations over the state. Only one day was spent in studying the New Ulm formations. A second day would have added somewhat to the list, yet doubtless all the dominant lichen floral elements were secured.

Without entering into a detailed analysis, it will appear from an inspection of the lichens composing the formations for shaded and for exposed rocks that the species occurring in the former are for most part foliaceous or fruticulose types, while those given for the latter are in general crustaceous, or if foliaceous, at least closely prostrate on the rocks. This is what would be expected, since shade favors better development of thallus, so that those species showing good thalli crowd out the other species in shaded places, or when unshaded become shaded with the growth of trees.

Next in order come the earth lichen formations of the rocky areas of Granite Falls and New Ulm. I shall first record the exposed formations for the two localities and compare with the similar formation already recorded for Pipestone. Then will follow the lichen formations of shaded earth at the first two stations, which is scarcely developed at Pipestone. A consideration of calcareous-earth lichen formations follows, the present being formations of non-calcareous earth.

Endocarpon hepaticum lichen formation of exposed earth (Granite Falls).

Heppia despreauxii (Mont.) Tuck.
Urceolaria scruposa (L.) Nyl.
Cladonia pyxidata (L.) Fr.
Biatora muscorum (Sw.) Tuck.
Biatora icterica Mont.
Endocarpon hepaticum Ach.
Endocarpon pusillum Hedw. var. **garovaglii** Kph.

Endocarpon hepaticum lichen formation of exposed earth (New Ulm).

Cladonia pyxidata (L.) Fr., CTS.

Cladonia turgida (EHRH.) HOFFM.
Biatora uliginosa (SCHRAD.) FR.
Endocarpon hepaticum ACH., CT.
Endocarpon pusillum HEDW. var. **garovaglii** KPH., C.

Comparing these lists with the one given for the corresponding formation at Pipestone, we find three common lichens which are marked (C) in the list above. Two of these marked (T) are also found in the similar formation at Taylors Falls, and one marked (S) is common in like formations in the lake Superior region. This plant is the most constant element in the exposed earth lichen formations of the State, and I should be disposed to name these *Cladonia pyxidata* lichen formations, were it not that the plant, though commonly present in exposed stations, thrives better in shaded ones. I must here emphasize that these, as well as the calcareous-earth lichen formations, grow on earth in rocky places where larger vegetation is scanty and scattered.

Next in order come lichen formations of shaded earth, partly composed of plants which grow also, though not so well, in unshaded places. From their dominant elements, these may be designated as follows:

Cladonia-Peltigera lichen formation of shaded earth (Mankato).

Peltigera rufescens (NECK.) HOFFM.
Peltigera canina (L.) HOFFM.
Peltigera canina (L.) HOFFM. var. **sorediata** SCHAER.
Collema pulposum (BERNH.) NYL.
Collema tenax (SW.) ACH.
Cladonia pyxidata (L.) FR.
Cladonia fimbriata (L.) FR.
Cladonia gracilis (L.) FR.
Cladonia gracilis (L.) FR. var. **verticillata** FR.

Cladonia-Peltigera lichen formation of shaded earth (Granite Falls).

Peltigera rufescens (NECK.) HOFFM., CT.
Peltigera canina (L.) HOFFM., CTS.
Peltigera canina (L.) HOFFM. var. **sorediata** SCHAER., CTS.
Collema pulposum (BERNH.) NYL., CT.

Cladonia pyxidata (L.) Fr., CTS.
Cladonia fimbriata (L.) Fr., C.
Cladonia fimbriata (L.) Fr. var. **tubæformis** Fr., TS.
Cladonia gracilis (L.) Nyl., CTS.
Cladonia gracilis (L.) Nyl. var. **verticillata** Fr., CTS.

These two formations are remarkably similar, having 8 common forms (C) of a total of nine lichens in each formation. Including the similar formation at Taylors Falls (T) we still have 7 lichens common to the similar formations for a large part of Minnesota, and extending the observation to the similar formation on Grand Portage island in the lake Superior (S) region, we yet have 6 lichens common to such formations selected from widely separated areas in the State. This is the first kind of formation thus far considered which is found in the Minneapolis area studied. Therefore data from this region have not been introduced thus far. Their use in the present consideration would not decrease the number of common elements, and I shall not add them. The three rarer *Cladonias* of the region under consideration in the present paper, *Cladonia symphycarpia* Fr., *Cladonia mitrula* Tuck. and *Cladonia cariosa* (Ach.) Spreng. have been purposely omitted, as there is yet doubt as to whether their adaptation is ombrophytic.

As to the nature of the lichens composing these earth lichen formations, it is apparent that those of the shaded earth formations are as a whole more foliaceous or fruticulose and better developed as to thallus than those of the exposed earth formation. The explanation is of course the same as that already given for exposed and shaded rock lichen formations.

I shall now consider the one remaining earth lichen formation at Granite Falls and compare it with a similar one in another region. It is that of the earth among the calcareous drift pebbles and small boulders on hill sides. From the calcareous nature of the earth and the presence of a *Biatora* seldom seen elsewhere than in such formations, the following name has suggested itself.

Biatora decipiens lichen formation of exposed calcareous earth (Granite Falls).

Heppia despreauxii (Mont.) Tuck.
Heppia polyspora Tuck.

Urceolaria scruposa (L.) NYL.
Biatora muscorum (SW.) TUCK.
Biatora decipiens (EHRH.) FR.
Biatora decipiens (EHRH.) FR. var. **dealbata** AUCT.
Endocarpon hepaticum ACH.

Some of the plants of this formation have been found at Mankato and also at Minneapolis, but the formation is not well developed at either place. However, it is beautifully developed at Fayette, Iowa, and because of its remarkable similarity there to the Granite Falls formation about two hundred miles distant, I give it below for the sake of comparative study.

Biatora decipiens lichen formation of exposed calcareous earth (Fayette, Iowa).

Heppia despreauxii (MONT.) TUCK., C.
Urceolaria scruposa (L.) NYL., C.
Biatora muscorum (SW.) TUCK., C.
Biatora decipiens (EHRH.) FR., C.
Biatora decipiens (EHRH.) FR. var. **dealbata** AUCT., C.
Biatora fossarum (DUF.) MONT.
Endocarpon hepaticum ACH., C.

It will be seen that the two formations are identical except that each one contains one species not found in the other. Again, this slight difference becomes less significant when it is stated that each of these two plants not found in both formations is rather rare in the formation in which it occurs. The six lichens common to both formations I have indicated in the Fayette list (C). In both localities the formations are formed on hill sides and seen to be somewhat better developed on southward than on northward slopes. I have not seen similar formations well developed elsewhere, but it is probable that they reach their best development on unshaded hill sides where other vegetation is scanty and where the lichens are washed with lime-impregnated water flowing down the slope during rains. *Biatora decipiens* (Ehrh.) Fr. and *Endocarpon hepaticum* Ach. are the most common plants of these formations, but the latter is quite as common in another formation of non-calcareous earth, which I have named for it, not confined to hill sides.

Closely related to the above formations are two occupying the same areas and named for a lichen almost wholly confined to them. They follow below:

Lecanora calcarea contorta lichen formation of exposed limestone pebbles (Granite Falls).

Placodium vitellinum (EHRH.) NAEG. and HEPP. var. **aurellum** ACH.

Lecanora calcarea (L.) SOMMERF. var. **contorta** FR.

Lecanora privigna (ACH.) NYL.

Lecanora privigna (ACH.) NYL. var. **pruinosa** AUCT.

Endocarpon pusillum HEDW.

Verrucaria muralis ACH.

Staurothele diffractella (NYL.) TUCK.

Like the last, this formation is not well developed in other studied portions of Minnesota, and I shall give the similar one for Fayette, Iowa, for comparison.

Lecanora calcarea contorta lichen formation of exposed limestone pebbles (Fayette, Iowa).

Placodium cinnabarinum (ACH.) AUZ.

Placodium vitellinum (EHRH.) NAEG. & HEPP. var. **aurellum** ACH., C.

Lecanora muralis (SCHREV.) SCHAER. var. **versicolor** FR.

Lecanora calcarea (L.) SOMMERF.

Lecanora calcarea (L.) SOMMERF. var. **contorta** FR., C.

Lecanora privigna (ACH.) NYL., C.

Rinodina bischoffii (HEPP.) KOERB.

Biatora russellii TUCK.

Endocarpon pusillum HEDW., C.

Verrucaria nigrescens PERS.

Verrucaria muralis ACH., C.

Lichens common to the two formations are marked (C) in the Fayette list, and comparison shows marked similarity in the two formations about 200 miles distant, except that the latter is considerably better developed than the former. This is as would be expected when we consider that the Iowa region is one where limestones abound, while the Minnesota is one in which the limestone pebbles are those transported in glacial drift and are less numerous. All the species of these formations, except the *Biatoras*, have been found elsewhere in Minnesota, but not aggregated into definite formations.

Comparing the last two series of formations, viz., those of calcareous earth and those of drift pebbles of the same areas, it will be noted that the former, because of their position on dry hill-sides, consist as a whole of lichens having small foliaceous or granular thalli, while those on the yet dryer and harder calcareous pebbles are almost entirely made up of strictly crustaceous plants.

The formations of exposed and shaded limestone bluffs come next in natural order, and the analysis is difficult, since some of the lichens of these formations grow about equally well in sunshine and shade. These I shall indicate by an interrogation point (?). From the prevalence of gelatinous lichens they may be named as follows:

Gelatinous lichen formation of shaded (or damp) limestone bluffs (Mankato).

Pannaria nigra (Huds.) Nyl.
Pannaria languinosa (Ach.) Koerb.
Omphalaria kansana Tuck.?
Omphalaria pulvinata Nyl.?
Collema plicatile Schaer.
Collema pustulatum Ach.
Leptogium lacerum (Sw.) Fr.
Placodium citrinum (Hoffm.) Leight.
Biatora inundata Fr.
Buellia alboatra (Hoffm.) Th. Fr. var. **saxicola** Fr.
Endocarpon miniatum (L.) Schaer.
Staurothele umbrina (Wahl.) Tuck.

Similar formations do not exist in other surveyed portions of Minnesota, except at Minneapolis, where the development is poor. It is as follows:

Gelatinous lichen formation of shaded (or damp) calcareous rocks (Minneapolis).

Pannaria nigra (Huds.) Nyl., C.
Pannaria languinosa (Ach.) Koerb., C.

Omphalaria sp.
Leptogium lacerum (Sw.) Fr., C.
Endocarpon miniatum (L.) Schaer., C.
Placodium citrinum (Hoffm.) Leight., C.

The plants of the Minneapolis list are all but one common (C) to both formations and may be regarded as characteristic of such formations. Since the last formation is poorly developed, I may add the similar one for Fayette, Iowa, which is better developed than either of the above.

Gelatinous lichen formation of shaded (or damp) calcareous rocks (Fayette, Iowa).

Pannaria nigra (Huds.) Nyl.
Pannaria languinosa (Ach.) Koerb.
Omphalaria pulvinata Nyl.?
Omphalaria umbella Tuck.?
Omphalaria sp.
Collema plicatile Schaer.?
Collema furvum (Ach.) Nyl.?
Collema pustulatum Ach.?
Leptogium lacerum (Sw.) Fr.
Leptogium chlorometum (Sw.) Nyl.
Placodium citrinum (Hoffm.) Leight.
Biatora trachona Flot.
Buellia alboatra (Hoffm.) Th. Fr. var. **saxicola** Fr.
Endocarpon miniatum (L.) Schaer.?
Staurothele umbrina (Wahl.) Tuck.?

The introduction of the Fayette formation is of special interest for the following reason. The first Minnesota formation is a mile back from the Minnesota river on a bluff along which the river once flowed, but which now is left dry except for the trees which overhang it and shade the lichens of the formation. The Fayette formation is on a bluff at the water's edge, and the plants are growing within one to ten feet of the water. Doubtless this in part causes the greater richness. The Mankato formation is an interrupted one, none of the plants persisting in wholly unshaded spots. The Fayette formation on the other hand, extends for miles, without complete interruption, wherever the bluffs exist. With the greater amount of moisture at the water's edge, some of the plants of the Fayette formation grow well in sunshine and even on south exposures. These I have indicated by an interrogation point (?). These, for most part gelatinous lichens, require a good amount of moisture; and if growing far from water seek shade for it. In the Fayette locality many trees have been cut recently along the bluffs so that the plants are more exposed than formerly. The Minneapolis list can be considered a formation only in the sense of a group of plants growing under like conditions, for owing to somewhat dryer climate the formation is poorly developed as to individuals and may be designated as a *scattered* formation, only one or two of the species usually growing in one limited area, along the bluffs and long stretches of bluff between these areas frequently not bearing a single plant of the formation.

Next in order comes the lichen formation of exposed limestone bluffs, which I shall designate as follows from the presence of a large proportion of angiocarpous lichens.

Angiocarpous lichen formation of limestone bluffs (Mankato).

Theloschistes lychneus (Nyl.) Tuck.

Placodium elegans (Link.) DC.

Placodium vitellinum (Ehrh.) Naeg. and Hepp var. **aurellum** Ach.

Placodium aurantiacum (Light.) Naeg. and Hepp.

Lecanora hageni Ach.

Lecanora erysibe Nyl.?

Endocarpon pusillum Hedw.?

Endocarpon miniatum (L.) Schaer.?

Staurothele diffractella (Nyl.) Tuck.

Verrucaria fuscella Fr.

Verrucaria nigrescens Pers.

Verrucaria muralis Ach.

I might add similar formations from Minneapolis and Fayette, Iowa; but the analysis is very uncertain so that the comparisons could have little value.

I shall now consider the sandstone bluff formations of certain localities, simply designating them as formations of damp sandstone since they are found along streams where the rocks are well supplied with moisture. The first of the formations is almost completely shaded, but the second is only partially shaded, moisture, the thing really sought by the plants, being sufficient in more or less exposed spots so that the less ombrophytic plants of the group thrive twenty or thirty feet from the water's surface, and even the more shade-loving ones are found in exposed spots nearer the water. I shall now record the formations as follows, designating the less ombrophytic plants of the second formation thus (?). For these formations I suggest the following name from a plant almost wholly confined to them in Minnesota.

Usnea barbata rubiginea lichen formation of damp sandstone bluffs (Minneopa Falls).

Ramalina calicaris (L.) FR. var. **farinacea** SCHAER.
Usnea barbata (L.) FR. var. **hirta** FR.
Usnea barbata (L.) FR. var. **rubiginea** MICHX.
Peltigera canina (L.) HOFFM. var. **sorediata** ACH.
Leptogium chloromelum (SW.) NYL.
Pannaria languinosa (ACH.) KOERB.
Cladonia furcata (HUDS.) FR.
Cladonia furcata (HUDS.) FR. var. **racemosa** FR.
Urceolaria scruposa (L.) NYL.

Usnea barbata rubiginea lichen formation of damp sandstone bluffs (Minneapolis).

Ramalina calicaris (L.) FR. var. **farinacea** SCHAER., C.
Usnea barbata (L.) FR. var. **hirta** FR., C.
Usnea barbata (L.) FR. var. **rubiginea** MICHX.? C.
Parmelia conspersa (EHRH.) ACH.? T.
Peltigera canina (L.) HOFFM. var. **sorediata** SCHAER., CE.
Pannaria languinosa (ACH.) KOERB., C.
Lecanora subfusca (L.) ACH. var. **coilocarpa** ACH.? T.
Urceolaria scruposa (L.) NYL.? C.
Cladonia cæspiticia (PERS.) FL., T.
Cladonia cornucopioides (L.) FR.? E.
Endocarpon pusillum (HEDW.) var. **garovaglii** KPH., E.

Comparing the two formations we find six common lichens of a total of nine recorded for the first and eleven for the second. Similar formations occur at Pictured Rocks, Iowa, and at Rapidan, but I shall not multiply lists. As in the instance of certain formations on shaded granite or quartzite recorded above, both of these formations are more or less mixed, being made up of lichens strictly lithophytic in adaptation and of others which have doubtless wandered from trees or from earth. As I have not been able to study such sandstone bluffs at a distance from trees, I have not attempted a definite analysis of these more limited formations as I did for the formations of the shaded granite and quartzite, but have simply indicated in the second list those which have probably wandered from trees by (T) and those from earth by (E). I have omitted from these sandstone formations some of the rarer plants which I should have included had I attempted an analysis of these mixed formations.

I shall now proceed to the two formations of trees, viz., that of rough barked trees and that of trees having smooth bark. The distinctions are difficult in some instances as certain species grow in both habitats. Consequently, as in some instances, in formations previously considered, some plants are recorded for more than one formation. Moreover, it must be added that some of those recorded for rough barked trees frequently seek the smoother portions of the bark. The subfamily *Parmelei* is especially well developed in the rough bark formations, which may accordingly be named as follows:

Parmelei lichen formation of trees with rough bark (Mankato).

Ramalina calicaris (L.) Fr. var. **fraxinea** Fr., G.
Ramalina calicaris (L.) Fr. var. **fastigiata** Fr., G.
Theloschistes chrysopthalmus (L.) Norm., G.
Theloschistes polycarpus (Ehrh.) Tuck., G.
Theloschistes lychneus (Nyl.) Tuck., G.
Theloschistes concolor (Dick.) Tuck., G.
Parmelia perforata (Jack.) Ach.
Parmelia crinita Ach., G.
Parmelia borreri Turn., G.
Parmelia tiliacea (Hoffm.) Floerk., G.
Parmelia saxatilis (L.) Fr.
Parmelia caperata (L.) Ach., G.

Physcia granulifera (ACH.) TUCK., G.
Physcia pulverulenta (SCHREB.) NYL., G.
Physcia stellaris (L.) TUCK., G.
Physcia tribacia (ACH.) TUCK.
Physcia obscura (EHRH.) NYL., G.
Physcia adglutinata (FLOERK.) NYL.
Collema pycnocarpum NYL., G.
Collema flaccidum ACH.
Leptogium myochroum (EHRH., SCHAER.) TUCK.
Placodium aurantiacum (LIGHT.) NAEG. and HEPP., G.
Placodium cerinum (HEDW.) NAEG. and HEPP., G.
Lecanora subfusca (L.) ACH., G.
Pertusaria pustulata (ACH.) NYL.
Pertusaria leioplaca (ACH.) SCHAER.
Pertusaria velata (TURN.) NYL.
Biatora rubella (EHRH.) RABENH.
Biatora fuscorubella (HOFFM.) TUCK., G.
Biatora subfusca FR., G.
Lecidea enteroleuca FR., G.
Buellia alboatra (HOFFM.) TH. FR., G.
Buellia parasema (ACH.) TH. FR.
Opegrapha varia (PERS.) FR., G.
Graphis scripta (L.) ACH., G.
Graphis scripta (L.) ACH. var. limitata ACH., G.
Arthonia lecideella NYL.
Arthonia radiata (PERS.) TH. FR., G.
Coniocybe pallida (PERS.) FR.
Pyrenula gemmata (ACH.) NAEG., G.
Pyrenula hyalospora NYL., G.
Pyrenula nitida ACH.
Pyrenula quinqueseptata (NYL.) TUCK.
Pyrenula leucoplaca (WALLR.) KBR., G.
Pyrenula megalospora sp. nov., G.

In order to avoid reproducing a large portion of the above long list of names, I have for the similar formation at Granite Falls marked those of the list found there (G) and add below the only one found in the Granite Falls formation and not at Mankato, viz., *Biatora naegelii* Tuck. Thus the mark (G) will indicate also those common to both formations and as a whole most characteristic of such lichen formations for the Minnesota valley. The Mankato area with its abundance of trees would, of course, be expected to possess richer tree lichen formations than Granite Falls, and with the exception of a single species, the rough bark formation of the latter area is but a partial repetition of that of the former.

The formation on trees with smooth bark at Mankato contains all but two of the species of the similar formation at Granite Falls, and the treatment may be abbreviated as the last two above. The genus *Pyrenula* predominates in the formation, and some of the species are among the lichens most characteristic of smooth bark. Therefore, the formations may receive the name which follows:

Pyrenula lichen formation of trees with smooth bark
(Mankato).

Theloschistes polycarpus (Ehrh.) Tuck.
Theloschistes concolor (Dicks.) Tuck., G.
Parmelia olivacea (L.) Ach., G.
Physcia adglutinata (Floerk.) Nyl., G.
Placodium cerinum (Hedw.) Naeg. and Hepp., G.
Lecanora subfusca (L.) Ach., G.
Rinodina sophodes (Ach.) Nyl., G.
Biatora fuscorubella (Hoffm.) Tuck., G.
Lecidea enteroleuca Fr., G.
Graphis scripta (L.) Ach., G.
Arthonia lecideella Nyl.
Arthonia dispersa Nyl., G.
Pyrenula punctiformis (Ach.) Naeg., F.
Pyrenula punctiformis (Ach.) Naeg. var. **fallax** Nyl., F.
Pyrenula nitida Ach., F.
Pyrenula thelena Ach., F.
Pyrenula cinerella (Flot.) Tuck., F.
Pyrenula cinerella (Flot.) Tuck. var. **quadriloculata** var. nov.
Pyrenula leucoplaca (Wallr.) Kbr., GF.

The two formed on smooth bark at Granite Falls and not at Mankato are *Lecidea enteroleuca* Fr. var. *achrista* Schaer. and *Arthonia punctiformis* Ach. As in the rough bark formations, the one at Mankato is richer for the same reason and, strangely enough, my study of the Granite Falls area only discovered a single *Pyrenula* on smooth bark. My name is scarcely appropriate for this formation, though it is for the one at Mankato as it would be for others from other localities in Minnesota and Iowa which might be added. Without adding another list or another complete formation, I have indicated by (F) in the above list the *Pyrenulas* of that list which occur on smooth bark at Fayette, Iowa.

Persons acquainted with lichen species will readily observe in the lists for rough bark and smooth bark lichen formations, that the formation on rough bark is composed principally of the more foliaceous and fruticulose lichens while those of the smooth bark formations are in the main crustaceous lichens. This is possibly due in part to the fact that these foliaceous and fruticulose lichens more easily gain a foothold on the rough bark which breaks up the thallus of the lichens adapted to smooth bark, thus tending to kill them. However it is probable that light, shade and moisture are also factors, the large trees furnishing more shade than the smaller ones.

Next in order naturally enough we may consider the lichen formations of old boards and old wood, and the formations are so nearly alike for Mankato and Granite Falls that they may be treated in a single list by giving the Mankato list and marking (G) those common to the Granite Falls formation also. Our *Calicei* are lichens seldom seen in any other formations, hence the following name may be applied.

Calicei lichen formation of old boards and wood
(Mankato).

Theloschistes chrysopthalmus (L.) Norm., G.

Placodium cerinum (Hedw). Naeg. and Hepp. var. **pyrocea** Nyl., G.

Lecanora hageni Ach., G.

Lecanora varia (Ehrh.) Nyl., G.

Rinodina sophodes (Ach.) Nyl., G.

Rinodina sophodes (Ach.) Nyl., var. **exigua** Fr., G.

Buellia parasema (Ach.) Th. Fr., G.

Buellia turgescens (Nyl.) Tuck.

Calicium parietinum Ach.

Thelocarpon prasinellum Nyl.

The additions for Granite Falls are *Cetraria ciliaris* (Ach.) Tuck., *Lecidea enteroleuca* Fr. and *Calicium quercinum* Ach. As in other instances the common forms are those most characteristic of such formations. I have not detected the *Calicium* for which I have named the Mankato formations at Granite Falls, where it is replaced by another species, and I shall add the species, *Acolium tigillare* (Ach.) Dn., which is one of the *Calicei* common in the similar formation at Fayette, Iowa, and the only one found in the like formation at Minneapolis. It must be admitted that the name used for these formations, while it may be applied, is not so appropriate for the related formations in the lake Superior region where some of the *Calicei* grow on living bark and yet others on rotting wood.

But one formation remains to be considered, viz., that of rotting stumps and prostrate logs. In these formations the most common plants are those of the genus *Cladonia* and the formations may accordingly receive the following name:

Cladonia formation of rotten wood (Mankato).

Peltigera canina (L.) Hoffm., G.

Peltigera canina (L.) Hoffm., var. **sorediata** Schaer.

Cladonia fimbriata (L.) Fr., G.

Cladonia fimbriata (L.) Fr. var. **tubæformis** Fr., G.

Cladonia gracilis (L.) Nyl., G.

Cladonia gracilis (L.) Nyl., var. **verticillata** Fr., G.

Cladonia symphycarpia Tuck.

Cladonia macilenta (Ehrh.) Hoffm.

Cladonia cristatella Tuck.

The only species found at Granite Falls in the similar formation and not at Mankato is *Biatora flexuosa* Fr. and the formation may, with this addition, be indicated by marking (G) those plants of the Mankato formation common to both. Comparison with formations from other localities would show some variation, but the *Cladonias* would predominate and give character to the formations. Wood commonly rots in moist shady places, furnishing an abundance of moisture, and we find accordingly that the formations on rotten wood are made up in large part of fruticulose lichens. The *Calicei* formations of old wood are exposed to drier conditions and are composed almost entirely of lichens having poorly developed thalli.

I must emphasize here that lichens of nearly all the formations enumerated above enjoy moist places, and that lack of moisture produces a decrease in richness both in size and number of individuals and in numbers of species in the formations. I repeat this, which I have established for some parts of Minnesota previously, because some persons may suppose that lichens, because of their xerophytic adaptations, thrive as well in the driest spots as in those affording more moisture. The exceptions to this general statement will appear from a careful study of the analyses made of the various formations.

The gelatinous lichen formation of shaded limestone (Minneapolis) has been called a *scattered* one, and I have explained what is meant by the expression. Others of the same kind are the *Cladonia-Peltigera* lichen formations of shaded earth, the angiocarpous lichen formations of exposed limestone bluffs, the *Calicei* lichen formations of old wood and in some instances the *Cladonia* lichen formations of rotten wood, though in other instances half or more of the species of *Cladonia* of the formation may be found on a single log. Thus formations of the kind last named and like the one first named in this paragraph differs from the other three named in the paragraph in that they may or may not be scattered while the three always are, so far as I know, except the *Calicei* formation which may be found nearly complete on a few rods of old fence in some favorable instances. The two formations of trees are widely extended; but they are not scattered as I have used the term since one commonly finds a good proportion of the species of either formation in passing a short distance in the woods.

Also in my classification we have the peculiar condition of two lichen formations occupying the same area. This is illustrated by the *Biatora decipiens* lichen formation of exposed calcareous earth and the *Lecanora calcarea contorta* lichen formation of exposed limestone pebbles, or by the *Lecanora* lichen formations of exposed granite or quartzite and the *Endocarpon hepaticum* lichen formation of exposed earth. Yet it is apparent that the formations are distinct in both instances, the division being based on substratum as well as amount of light and moisture.

As a whole, the formations may be said to be azonal and without definite form or extent, both depending upon location of proper substrata, protection from or exposure to light, etc.

In my paper I have used the expression "lichen formation" to include lichens only. Of course, these plants are in some instances found growing upon the same substrata and in the same general set of conditions as plants of other groups, and which might have been listed in the formations. However, I may be excused, in a paper on lichen distribution, for omitting other plants than lichens, especially since I could not possibly have treated the other plants with the same detail that I have accorded the lichens.

I know of no other paper which has dealt exclusively with lichen distribution as I have done herein, and surely this analysis must be helpful in the study of the lichen flora of other regions. The multiplicity of observations necessary for such a detailed study are not easy to make, and I am sure that much of interest has escaped me. However, I hope that this paper may stimulate others to study the lichens from an ecologic point of view.

LIST OF SPECIES AND VARIETIES.

1. **Ramalina calicaris** (L.) FR. var. **fraxinea** FR.

On trees and old wood, infrequent or rare. Mankato, June 23, 1899, no. 55, June 26, 1899, no. 102, and June 28, 1899, no. 164. Granite Falls, July 11, 1899, no. 385 and July 13, 1899, nos. 510 and 533.

2. **Ramalina calicaris** (L.) FR. var. **fastigiata** FR.

On trees and rocks, rare. Mankato, June 23, 1899, no. 54. New Ulm, July 5, 1899, no. 275. Granite Falls, July 14, 1899, no. 518, and July 17, 1899, no. 588.

3. **Ramalina calicaris** (L.) FR. var. **farinacea** SCHAER.

On sandstone and granite. Mankato (Minneopa Falls), June 27, 1899, no. 154. Redwood Falls, July 6, 1899, no. 305, and July 8, 1899, no. 349. Granite Falls, July 12, 1899, no. 460.

4. **Ramalina polymorpha** (ACH.) TUCK. ?

On shaded granitic rocks in first locality and on a large bowlder in the second, rare. Granite Falls, July 12, 1899, no.

456, and July 13, 1899, no. 492. Pipestone, July 19, 1899, no. 641.

The plants are placed here provisionally.

They resemble in part *Ramalina calicaris* (L.) Fr. var. *farinacea* Schaer.

Not previously reported from Minnesota and new to the Mississippi valley.

5. **Cetraria ciliaris** (ACH.) TUCK.

A single sterile specimen collected on an old cedar stump. Granite Falls, July 17, 1899, no. 570.

6. **Usnea barbata** (L.) FR. var. **florida** FR.

On an old stump, only seen once and then sterile. Granite Falls, July 17, 1899, no. 565.

7. **Usnea barbata** (L.) FR. var. **hirta** FR.

On sandstone, rare. Mankato (Minneopa), June 27, 1899, no. 151.

8. **Usnea barbata** (L.) FR. var. **rubiginea** MICHX.

On sandstone and granite rocks, rare. Mankato (Minneopa Falls), June 27, 1899, no. 152. Redwood Falls, July 8, 1899, no. 350.

9. **Theloschistes chrysopthalmus** (L.) NORM.

On trees and old boards, rare or infrequent except at Granite Falls, where the plant is frequent. Mankato, June 22, 1899, no. 9. Mankato (Rapidan), June 28, 1899, no. 163. New Ulm, July 4, 1899, nos. 226 and 227. Redwood Falls, July 6, 1899, no. 302, and July 8, 1899, no. 340. Granite Falls, July 11, 1899, no. 387, and July 15, 1899, no. 549.

10. **Theloschistes polycarpus** (EHRH.) TUCK.

On trees and rocks, rare. Mankato, June 26, 1899, no. 107. Granite Falls, July 12, 1899, no. 447, and July 15, 1899, no. 531.

11. **Theloschistes lychneus** (NYL.) TUCK.

On trees and rocks, frequent. Mankato, June 22, 1899, no. 5. New Ulm, July 5, 1899, no. 263. Redwood Falls, July 8, 1899, no. 330. Granite Falls, July 11, 1899, no. 438, and July 17, 1899, no. 579.

12. **Theloschistes concolor** (DICKS.) TUCK.

On trees and old wood, common at the first locality and rare at the second. Mankato, June 22, 1899, no. 7. Granite Falls, July 11, 1899, no. 377.

13. **Theloschistes concolor** (DICKS.) TUCK. var. **effusa** TUCK.

On trees rare. Mankato, July 1, 1899, no. 216a.

14. **Parmelia perforata** (JACQ.) ACH.

On trees, rare. Mankato, June 26, 1899, no. 134.

15. **Parmelia cetrata** ACH.

On trees and rocks, rare except at the last locality where the plant is frequent. New Ulm, July 4, 1899, no. 228. Redwood Falls, July 8, 1899, nos. 329 and 360. Granite Falls, July 12, 1899, no. 455, and July 17, 1899, nos. 550, 573 and 574.

16. **Parmelia crinita** ACH.

On trees and granitic rocks, rare. Mankato, June 23, 1899, no. 47. Mankato (Minneopa Falls), June 27, 1899, no. 133. New Ulm, July 5, 1899, no. 258. Granite Falls, July 11, 1899, nos. 400 and 439.

17. **Parmelia borreri** TURN.

On trees and granitic rocks, common. Mankato, June 22, 1899, no. 11. New Ulm, July 5, 1899, no. 288. Redwood Falls, July 8, 1899, no. 335. Granite Falls, July 11, 1899, nos. 383 and 389.

18. **Parmelia borreri** TURN. var. **rudecta** TUCK.

On trees and old wood, infrequent. Mankato, June 23, 1899, no. 12, and July 23, 1899, no. 58.

19. **Parmelia borreri** TURN. var. **hypomela** TUCK.

On shaded granite rocks, rare and sterile. New Ulm, July 5, 1899, no. 287.

20. **Parmelia tiliacea** (HOFFM.) FLOERK.

On trees, infrequent. Mankato, June 23, 1899.

21. **Parmelia saxatilis** (L.) FR.

On trees and rocks, rare. Mankato, June 26, 1899, no. 106. New Ulm, July 5, 1899, no. 264. Redwood Falls, July 8, 1899, no. 341. Granite Falls, July 11, 1899, no. 414.

22. **Parmelia saxatilis** (L.) FR. var. **sulcata** NYL.

On old wood and shaded rocks, rare. Mankato (Rapidan), June 28, 1899, no. 165. Granite Falls, July 17, 1899, no. 586.

23. **Parmelia saxatilis** (L.) FR. var. **panniformis** (ACH. (SCHAER.?

On shaded rocks, rare. New Ulm, July 5, 1899, no. 268. Granite Falls, July 17, 1899, no 561.

The plant is placed here provisionally.

Not previously reported from Minnesota and new to the Mississippi valley.

24. **Parmelia olivacea** (L.) Ach.

On trees and old wood, rare. Mankato, June 23, 1899, no. 61. Granite Falls, July 15, 1899, no. 537.

25. **Parmelia olivacea** (L.) ACH. var. **prolixa** ACH.

On granitic rocks, quartzite, pipestone and once collected on earth, frequent except at the first locality, where it is rare. Morton, July 7, 1899, no. 315. Granite Falls, July 11, 1899, no. 405. Pipestone, July 18, 1899, nos. 594, 609 and 621, and July 19, 1899, no. 643.

26. **Parmelia caperata** (L.) ACH.

On trees and granitic rocks, frequent. Mankato, June 23, 1899, no. 53. Mankato (Minneopa) June 27, 1899, no. 153. New Ulm, July 5, 1899, no. 285. Granite Falls, July 11, 1899, no. 441.

27. **Parmelia conspersa** (EHRH.) ACH.

On granitic rocks, quartzite and pipestone, common or abundant. New Ulm, July 5, 1899, no. 269. Granite Falls, July 12, 1899, no. 449. Pipestone, July 18, 1899, no. 589, and July 19, 1899, no. 637.

28. **Physcia speciosa** (WULF., ACH.) NYL.

On rocks and mossy bases of trees, infrequent. Mankato, June 22, 1899, no. 13. New Ulm., July 5, 1899, no. 281. Granite Falls, July 11, 1899, no. 374.

29. **Physcia granulifera** (ACH.) TUCK.

On trees, rare. Mankato, June 24, 1899, no. 84. Granite Falls, July 11, 1899, no. 372.

30. **Physcia pulverulenta** (SCHREB.) NYL.

On rocks and trees, frequent. Mankato, June 23, 1899, no. 52. New Ulm, July 5, 1899, no. 286. Granite Falls, July 11, 1899. no. 383.

31. **Physcia stellaris** (L.) TUCK.

On trees and rocks, common or abundant. Mankato, June 23, 1899, no. 1. New Ulm, July 5, 1899, no 297. Granite Falls, July 11, 1899 no. 431, and July 13, 1899, no. 481.

32. **Physcia stellaris** (L.) TUCK. var. **apiola** NYL.

On granitic rocks, infrequent. Mankato, June 23, 1899, no. 44. Granite Falls, July 12, 1899, no. 463.

33. **Physcia tribacia** (ACH.) TUCK.

On wood, granite and quartzite, rare. Mankato, June 23, 1899, no. 77, and July 1, 1899, no. 216. Granite Falls, July 14, 1899, no. 517. Pipestone, July 18, 1899, no. 601 and July 19, 1899, no. 634.

34. **Physcia cæsia** (HOFFM.) NYL.

On bowlders and all kinds of rocks in the region, except limestone, frequent. Mankato, June 23, 1899, no. 76. New Ulm, July 5, 1899, nos. 290 and 296. Granite Falls, July 12, 1899, no. 443. Pipestone, July 18, 1899, nos. 618 and 624.

35. **Physcia obscura** (EHRH.) NYL.

On trees and rocks, common. Mankato, June 1899, no. 76a. New Ulm, July 5, 1899, no. 289. Granite Falls, July 11, 1899, no. 378, and July 17, 1899, no. 583.

36. **Physcia adglutinata** (FLOERK.) NYL.

On trees, frequent. Mankato, June 23, 1899, no. 45. Granite Falls, July 11, 1899, no. 382 and July 13, 1899, no. 482.

37. **Pyxine sorediata** FR.

On granitic rocks, rare. Granite Falls, July 17, 1899, no. 578.

38. **Peltigera rufescens** (NECK.) HOFFM.

On earth and mossy rocks, frequent. Mankato, June 25, 1899, no. 48. Mankato (Minneopa Falls), June 27, 1899, no. 150. New Ulm, July 5, 1899, no. 251. Granite Falls, July 11, 1899, no. 395 and July 17, 1899, no. 559.

39. **Peltigera canina** (L.) HOFFM.

On earth and rocks, common. Mankato (Minneopa Falls), June 27, 1899, no. 149. New Ulm, July 5, 1899, no. 262. Granite Falls, July 11, 1899, no. 390, and July 17, 1899, no. 580.

40. **Peltigera canina** (L.) HOFFM. var. **spongiosa** TUCK.

On earth, rare. Redwood Falls, July 8, 1899, no. 357. Not previously reported from Minnesota.

41. **Peltigera canina** (L.) HOFFM. var. **spuria** ACH.

On earth, rare. Mankato (Rapidan), June 28, 1899, no. 161.

42. **Peltigera canina** (L.) HOFFM. var. **sorediata** SCHAER.

On earth and old wood, rare, Mankato, June 26, 1899, no. 121. New Ulm, July 5, 1899, no. 260. Granite Falls, July 13, 1899, no. 512.

43. **Peltigera horizontalis** (L.) Hoffm.

On shaded earth, frequent locally. Redwood Falls, July 6, 1899, no. 301.

44. **Heppia despreauxii** (Mont.) Tuck.

On earth, rare at first locality and frequent at second. Mankato (Rapidan) June 28, 1899, no. 177. Granite Falls, July 11, 1899, no. 394, July 13, 1899, no. 507 and July 14, 1899, no. 522.

Not previously reported from Minnesota.

45. **Heppia polyspora** Tuck.?

On earth, rare. Granite Falls, July 13, 1899, no. 498. Spores spherical or subspherical, $\frac{5-8}{5-8}$ mic. This exceeds Tuckerman's measurements. Apothecia occasionally surpassing one mm. in diameter. I may later find it necessary to separate this as new species.

Not previously reported from Minnesota.

46. **Pannaria languinosa** (Ach.) Koerb.

On various rocks, earth and trees in shaded places, common or abundant. Mankato, June 23, 1899, no. 50. New Ulm, July 5, 1899, no. 280. Granite Falls, July 11, 1899, no. 396, and July 17, 1899, no. 569.

47. **Pannaria microphylla** (Sw.) Delis.

On shaded granite, infrequent. Redwood Falls, July 8, 1899, no. 345. Granite Falls, July 11, 1899, no. 384.

48. **Pannaria nigra** (Huds.) Nyl.

On limestone, common locally. Mankato, June 24, 1899, no. 95.

49. **Ephebe pubescens** Fr.

On quartzite, rare. New Ulm, July 5, 1899, no. 257.

50. **Pyrenopsis phæococca** Tuck.

On bowlders, rare. Mankato, June 23, 1899, no. 74.

Not previously reported from Minnesota and new to the Mississippi valley.

51. **Pyrenopsis melambola** Tuck.?

On bowlders, frequent. Mankato, June 29, 1899, no. 189. Spores somewhat small (7–10 x 4–5½ mic.).

Not previously reported from Minnesota and new to the Mississippi valley.

52. **Omphalaria kansana** TUCK.

On limestone, locally frequent. Mankato, June 23, 1899, no. 27.

Not previously reported from Minnesota.

53. **Omphalaria pulvinata** NYL.

On limestone, rare. Mankato, June 27, 1899, no. 148.

Not previously reported from Minnesota.

54. **Omphalaria phyllisca** (WAHL.) TUCK.

On granitic rocks, rare. Redwood Falls, July 6, 1899, no. 360, and July 8, 1899, nos. 338 and 343. Granite Falls, July 17, 1899, nos. 572 and 584.

Not previously reported from Minnesota and new to the Mississippi valley.

55. **Collema pycnocarpum** NYL.

On trees and once on rocks, generally distributed in the Minnesota valley, but rare.

Mankato, June 23, 1899, no. 60, and June 24, 1899, nos. 89 and 97. Mankato (Minneopa Falls), June 27, 1899, no. 136. Redwood Falls, July 6, 1899, no. 309, and July 8, 1899, no. 355. Granite Falls, July 11, 1899, no. 380.

56. **Collema flaccidum** ACH.

On trees and rocks, rare. Mankato, June 23, 1899, no. 81. Mankato (Minneopa), June 27, 1899, no. 137. New Ulm, July 5, 1899, no. 278.

57. **Collema pulposum** (BERNH.) NYL.

On earth and rocks, common in first locality. Mankato, June 22, 1897, no. 3, and June 23, 1899, no. 79. Granite Falls, July 11, 1899, no. 417.

58. **Collema tenax** (SW.) ACH.

On earth, rare. Mankato (Rapidan), June 28, 1899, no. 169.

Not previously reported from Minnesota.

59. **Collema plicatile** SCHAER.

On calcareous rocks, locally frequent. Mankato, June 23, 1899, no. 28.

Not previously reported from Minnesota.

60. **Collema pustulatum** ACH.

On calcareous rocks, rare. Mankato, June 26, 1899, no. 111.

Not previously reported from Minnesota.

61. **Collema furvum** (ACH.) NYL.

On shaded rocks, infrequent. New Ulm, July 5, 1899, no. 283. Redwood Falls, July 6, 1899, no. 307. Granite Falls, July 11, 1899, no. 391.

Not previously reported from Minnesota.

62. **Leptogium lacerum** (SW.) FR.

On various rocks, usually shaded, frequent. Mankato, June 23, 1899, no. 49. Redwood Falls, July 8, 1899, no. 328. Granite Falls, July 13, 1899, nos. 480 and 497 and July 17, 1899, no. 568.

63. **Leptogium pulchellum** (ACH.) NYL.

Collected once on a large bowlder in a shaded ravine, rare. Mankato, July 1, 1899, no. 212.

Not previously reported from Minnesota.

64. **Leptogium chloromelum** (SW.) NYL.

On mossy, shaded sandstone, rare. Mankato (Minneopa Falls), June 27, 1899, no. 144.

65. **Leptogium myochroum** (EHRH., SCHAER.) TUCK.

On trees and shaded granitic rocks, rare. Mankato, June 26, 1899, no. 126. Mankato (Rapidan), June 28, 1899, no. 166. Granite Falls, July 11, 1899, no. 392.

66. **Placodium elegans** (LINK.) DC.

On various rocks; common at Granite Falls, infrequent elsewhere. Mankato, June 24, 1899, no. 83. Redwood Falls, July 8, 1899, no. 353. Granite Falls, July 11, 1899, no. 440. Pipestone, July 18, 1899, nos. 592 and 603.

67. **Placodium murorum** (HOFFM.) DC.

On granitic rocks, rare. Granite Falls, July 12, 1899, no. 452.

68. **Placodium cinnabarrinum** (ACH.) AUZ.

On various rocks, frequent or common. Mankato, June 23, 1899, no. 73, and June 30, 1899, no. 200. Morton, July 7, 1899, no. 320. North Redwood, July 10, 1899, no. 369. Granite Falls July 11, 1899, no. 411. Pipestone, July 18, 1899, no. 607.

69. **Placodium aurantiacum** (LIGHTF.) NAEG. and HEPP.

On trees and rocks, common at first locality. Mankato, June 22, 1899, no. 19, and June 23, 1899. no. 38. Granite Falls, July 11, 1899, no. 375.

70. **Placodium citrinum** (HOFFM.) LEIGHT.

On limestone, rare. Mankato, June 26, 1899, no. 117.

71. **Placodium cerinum** (HEDW.) NAEG. and HEPP.

On trees and old wood, common. Mankato, June 22, 1899, no. 18, and June 23, 1899, no. 75. Mankato (Rapidan), June 28, 1899, nos. 178 and 179. Granite Falls, July 11, 1899, nos. 432 and 435. Granite Falls, July 17, 1899, no. 553.

72. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **sideritis** TUCK.

On granitic rocks and catlinite, common. Mankato, June 23, 1899, no. 41, June 26, 1899, no. 114, and June 30, 1899, no. 198. New Ulm, July 5, 1899, no. 247. Granite Falls, July 12, 1899, no. 444. Pipestone, July 18, 1899, no. 613.

73. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **pyracea** NYL.

On old boards, infrequent. Mankato, June 22, 1899, no. 2. Granite Falls, July 11, 1899, no. 430.

74. **Placodium ferrugineum** (HUDS.) HEPP.

On old wood, rare. Mankato, June 22, 1899, no. 17.

Not previously reported from Minnesota.

75. **Placodium ferrugineum** (HUDS.) HEPP. var. **pollinii** TUCK.

On dead cedars, rare. New Ulm, July 4, 1899, no. 230.

Not previously reported from Minnesota.

76. **Placodium vitellinum** (EHRH.) NAEG. and HEPP.

On granite and quartzite, common. Mankato, June 30, 1899, no. 203. New Ulm, July 5, 1899, no. 292. Granite Falls, July 12, 1899, no. 462. Pipestone, July 18, 1899, no. 629.

77. **Placodium vitellinum** (EHRH.) NAEG. and HEPP. var. **aurellum** ACH.

On granite, quartzite and sandstone, frequent. Mankato, June 22, 1899, no. 10. New Ulm, July 4, 1899, nos. 233, 237 and 239. Granite Falls, July 14, 1899, no. 523.

78. **Lecanora** sp.

On granitic rocks, frequent locally. Granite Falls, July 11, 1899, no. 408. Spores $\frac{13\text{–}16}{8\text{–}9.5}$ mic. Seems near *Lecanora gelida* (L.) Ach., but the thallus is probably too rough and heavy.

Not previously reported from Minnesota and new to the Mississippi Valley.

79. **Lecanora rubina** (VILL.) ACH.

On granite, quartzite and pipestone, common. Mankato (Rapidan), June 28, 1899, no. 160. New Ulm, July 5, 1899, no. 248. Granite Falls, July 11, 1899, no. 401 and July 12, 1899, no. 451. Pipestone, July 18, 1899, no. 617, and July 19, 1899, no. 644.

80. **Lecanora rubina** (VILL.) ACH. var. **heteromorpha** ACH.

With the last, frequent. New Ulm, July 5, 1899, no. 266. North Redwood, July 10, 1899, no. 361. Granite Falls, July 11, 1899, no. 409. Pipestone, July 18, 1899, and July 19, 1899, no. 642.

81. **Lecanora muralis** (SCHREB.) SCHAER.

On calcareous rocks, granite and quartzite, common at Granite Falls, rare elsewhere. Mankato, June 24, 1899, no. 85. Granite Falls, July 11, 1899, no. 406. Pipestone, July 18, 1899, no. 630.

82. **Lecanora muralis** (SCHREB.) SCHAER. var. **versicolor** FR.

On calcareous rocks, rare. Mankato, June 30, 1899, no. 196.

83. **Lecanora muralis** (SCHREB.) SCHAER. var. **saxicola** SCHAER.

On granitic rocks and catlinite, frequent. Mankato, June 30, 1899, no. 202. North Redwood, July 10, 1899, no. 370. Pipestone, July 19, 1899, no. 638.

84. **Lecanora frustulosa** (DICKS.) MASS.

On rocks, rare. Redwood Falls, July 8, 1899, no. 351. North Redwood, July 10, 1899, no. 371. Granite Falls, July 11, 1899, no. 410.

85. **Lecanora subfusca** (L.) ACH.

On trees and rocks, common at Mankato only. Mankato, June 23, 1899, no. 43, and June 26, 1899, no. 125. New Ulm, July 5, 1899, no. 271. Granite Falls, July 11, 1899, no. 376.

86. **Lecanora subfusca** (L.) ACH. var. **allophana** ACH.

On granitic rocks, infrequent. Granite Falls, July 11, 1899, nos. 403 and 407.

Not previously reported from Minnesota:

87. **Lecanora subfusca** (L.) ACH. var. **argentata** ACH.

On trees, rare. Mankato, June 23, 1899, no. 78.

88. **Lecanora subfusca** (L.) Ach. var. **coilocarpa** Ach.

On trees, granite and sandstone, rare. Mankato (Rapidan), June 28, 1899, no. 163a. Mankato, July 1, 1899, no. 210. Granite Falls, July 12, 1899, no. 446.

89. **Lecanora subfusca** (L.) Ach. var. **distans** Ach.

On sandstone, rare. Mankato (Rapidan), June 28, 1899, no. 182.

90. **Lecanora hageni** Ach.

On calcareous and granitic rocks and on old boards, common. Mankato, June 21, 1899, no. 91, and July, 1, 1899, nos. 215, 217 and 218. Granite Falls, July 11, 1899, nos. 426 and 436, and July 13, 1899, no. 506.

91. **Lecanora varia** (Ehrh.) Nyl.

On old wood and trees, infrequent. Mankato, June 24, 1899, no. 86. Mankato (Rapidan), June 28, 1899, no. 159. New Ulm, July 5, 1899, no. 280. Granite Falls, July 11, 1899, no. 386.

92. **Lecanora erysibe** Nyl.

On granitic rocks, rare. Mankato, June 23, 1899, no. 63, and June 26, 1899, no. 131. Granite Falls, July 13, 1899, no. 504.

93. **Lecanora cinerea** (L.) Sommerf.

On granite, quartzite and catlinite, common. Mankato, June 6, 1899, no. 62. New Ulm, July 5, 1899, no. 261. Granite Falls, July 13, 1899, no. 493. Pipestone, July 18, 1899, nos. 625 and 633.

94. **Lecanora cinerea** (L.) Sommerf. var. **lævata** Fr.

On quartzite, rare. New Ulm, July 5, 1899, no. 277.

95. **Lecanora cinerea** (L.) Sommerf. var. **gibbosa** Nyl.

On bowlders, rare. Mankato, July 1, 1899, no. 221.

96. **Lecanora calcarea** (L.) Sommerf.

On limestone, rare. Mankato, June 29, 1899, no. 188.

97. **Lecanora calcarea** (L.) Sommerf. var. **contorta** Fr.

On limestone, drift pebbles and granite, infrequent. Mankato, June 30, 1899, no. 199. Redwood Falls, July 8, 1899, no. 333. Granite Falls, July 11, 1899, no. 402, and July 14, 1899, no. 524.

98. **Lecanora xanthophana** Nyl.

On granite, quartzite and pipestone, common. Mankato, June 30, 1899, no. 197. New Ulm, July 5, 1899, no. 246. Morton, July 7, 1899, no. 313. Redwood Falls, July 8, 1899, no. 331. North Redwood, July 10, 1899, no. 368. Granite Falls, July 11, 1899, no. 418. Pipestone, July 18, 1899, nos. 598 and 611.

99. **Lecanora cervina** (Pers.) Nyl.

On bowlders and sandstone, infrequent. Mankato (Rapidan), June 28, 1899, no. 179. Mankato, June 29, 1899, no. 192.

100. **Lecanora cervina** (Pers.) Nyl. var. **cinereoalba** var. nov.

On granite, frequent. Mankato, June 29, 1899, no. 190. Granite Falls, July 11, 1899, nos. 385 and 403, and July 12, 1899, no. 404.

Thallus gray or grayish white.

101. **Lecanora fuscata** (Schrad.) Th. Fr.

On bowlders, common at Mankato. Mankato, June 29, 1899, no. 191. Granite Falls, July 12, 1899, no. 450.

102. **Lecanora bookii** (Fr.) Th. Fr.

On limestone, rare. Mankato, June 29, 1899, no. 193.

Not previously reported from Minnesota and new to the Mississippi valley.

103. **Lecanora privigna** (Ach.) Nyl.

On sandstone and calcareous drift pebbles, rare. Mankato (Rapidan), June 28, 1899, no. 171. Granite Falls, July 13, 1899, no. 508.

104. **Lecanora privigna** (Ach.) Nyl. var. **pruinosa** Auct.

With last on same substrata, rare. Mankato (Rapidan), June 28, 1899, no. 170. Granite Falls, July 14, 1899, no. 514.

105. **Rinodina oreina** (Ach.) Mass.

On granitic rocks, quartzite and catlinite, abundant. Mankato, June 30, 1899, no. 201. New Ulm, July 5, 1899, no. 245. North Redwood, July 10, 1899, no. 367. Pipestone, July 18, 1899, nos. 602, 603 and 605.

106. **Rinodina sophodes** (Ach.) Nyl.

On trees, old wood and rocks, abundant. Mankato, June 23, 1899, no. 33, June 24, 1899, no. 93, and June 26, 1899, no. 115. New Ulm, July 5, 1899, nos. 267, 295 and 298. Granite Falls, July 11, 1899, nos. 427 and 428, and July 13, 1899, nos. 469, 486, 487 and 491.

107. **Rinodina sophodes** (Ach.) Nyl. var. **tephraspis** Tuck.
On quartzite, rare. Pipestone, July 18, 1899, no. 632.
Not previously reported from Minnesota.

108. **Rinodina sophodes** (Ach.) Nyl. var. **exigua** Fr.
On old wood, locally common. Mankato, June 22, 1899, no. 22. Granite Falls, July 11, 1899, no. 434.

109. **Rinodina bischoffii** (Hepp.) Koerb.
On limestone and granite, rare. Mankato, June 29, 1899, no. 194. Morton, July 7, 1899, no. 316.
Not previously reported from Minnesota.

110. **Rinodina lecanorina** Mass.
On boulders, rare. Mankato, June 26, 1899, no. 127.
Not previously reported from Minnesota and new to North America.

111. **Pertusaria velata** (Turn.) Nyl.
On trees, rare. Mankato (Minneopa Falls), June 26, 1899, no. 135.

112. **Pertusaria pustulata** (Ach.) Nyl.
On trees, rare. Mankato, June 23, 1899, no. 30, and July 1, 1899, no. 214.

113. **Pertusaria leioplaca** (Ach.) Schaer.
On trees, rare. Mankato, June 23, 1899, no. 68.

114. **Urceolaria scruposa** (L.) Nyl.
On earth and rocks, infrequent. Mankato, June 26, 1899, no. 128. Mankato (Rapidan), June 28, 1899, no. 187. Redwood Falls, July 8, 1899, no. 332. Granite Falls, July 11, 1899, no. 393. Pipestone, July 19, 1899, no. 640.

115. **Urceolaria actinostoma** Pers.
On granite, rare. Granite Falls, July 11, 1899, no. 416.
Not previously reported from Minnesota.

116. **Stereocaulon paschale** (L.) Fr.
On mossy rocks, only seen once in small quantity. Redwood Falls, July 8, 1899, no. 359.

117. **Cladonia symphycarpia** Fr. var. **epiphylla** (Ach.) Nyl.
On earth, rare. Mankato, June 26, 1899, no. 108.

118. **Cladonia mitrula** Tuck.
On earth, rare. Mankato, June 26, 1899, no. 98. Granite Falls, July 11, 1899, no. 436. The last a small form approaching *Cladonia cæspiticia* (Pers.) Fl.

119. **Cladonia cariosa** (ACH.) SPRENG.

On earth, rare. Mankato, June 26, 1899, no. 103. Redwood Falls, July 8, 1899, no. 336. Granite Falls, July 17, 1899, no. 587.

120. **Cladonia pyxidata** (L.) FR.

On earth, common or frequent. Mankato, June 26, 1899, no. 104. Mankato (Rapidan), June 28, 1899, no. 168. New Ulm, July 5, 1899, nos. 272 and 276, July 11, 1899, no. 397, July 12, 1899, no, 453, and July 17, 1899, no. 562. Pipestone, July 18, 1899, no. 627.

121. **Cladonia fimbriata** (L.) FR.

On earth, rare. Mankato, June 26, 1899, no 123. Granite Falls, July 12, 1899, no. 582. Pipestone, July 18, 1899, no. 604.

122. **Cladonia fimbriata** (L.) FR. var. **tubæformis** FR.

On old wood and earth, rare. Mankato, June 26, 1899, no. 124. New Ulm, July 5, 1899, no. 279. Granite Falls, July 11, 1899, no. 425, July 13, 1899, no. 495, and July 17, 1899, nos. 551 and 563.

123. **Cladonia fimbriata** (L.) FR. var. **radiata** FR.

On earth, rare. Redwood Falls, July 8, 1899, no. 337.

124. **Cladonia gracilis** (L.) NYL.

On old wood and earth, frequent at Mankato, elsewhere rare. Mankato, June 22, 1899, no. 4, and June 26, 1899, no. 100. Granite Falls, July 13, 1899, nos. 468 and 488, and July 17, 1899, no. 556.

125. **Cladonia gracilis** (L.) NYL. var. **symphycarpia** TUCK.

On old wood, rare. Mankato, June 26, 1899, no. 99.

126. **Cladonia gracilis** (L.) NYL. var. **verticillata** FR.

On earth, rare. Mankato, June 26, 1899, no. 101. Granite Falls, July 17, 1899, no. 557.

127. **Cladonia gracilis** (L.) NYL. var. **hybrida** SCHAER.

On earth, rare. Mankato (Rapidan), June 28, 1899, no. 158. Redwood Falls, July 8, 1899, no. 347.

128. **Cladonia turgida** (EHRH.) HOFFM.

On earth, rare. New Ulm, July 5, 1899, no. 253.

129. **Cladonia cæspiticia** (PERS.) FL.

On earth, rare. Redwood Falls, July 8, 1899, no. 342. Granite Falls, July 17, 1899, no. 555.

130. **Cladonia furcata** (HUDS.) FR.

On earth, rare. Mankato (Minneopa Falls), June 27, 1899, nos. 155 and 157.

131. **Cladonia furcata** (HUDS.) FR. var. **racemosa** FL.

On earth in shaded places, rare. Mankato (Minneopa Falls), June 27, 1899, no. 156. Redwood Falls, July 8, 1899, no. 334.

132. **Cladonia furcata** (HUDS.) FR. var. **pungens** FR.

On earth, rare. Redwood Falls, July 6, 1899, no. 303.

133. **Cladonia rangiferina** (L.) HOFFM.

On earth, frequent locally among granitic rocks. New Ulm, July 5, 1899, no. 252.

134. **Cladonia rangiferina** (L.) HOFFM. var. **sylvatica** L.

On earth, rare. Redwood Falls, July 8, 1899, no. 358.

135. **Cladonia macilenta** (EHRH.) HOFFM.

On old wood, rare. Mankato, June 29, 1899, no. 195.

136. **Cladonia cristatella** TUCK.

On old stumps, rare. Mankato (Rapidan), June 28, 1899, no. 162. Redwood Falls, July 8, 1899, no. 356. Granite Falls, July 13, 1899, no. 467 and July 17, 1899, no. 575.

137. **Cladonia cristatella** TUCK. var. **paludicola** TUCK.

Once collected on an old log. Mankato, June 26, 1899, no. 122. Squamules not powdery.

Not previously reported from Minnesota, and new to the upper Mississippi valley.

138. **Biatora decipiens** (EHRH.) FR.

Common on earth containing calcareous drift pebbles. Granite Falls, July 13, 1899, no. 500.

Not previously reported from Minnesota.

139. **Biatora decipiens** (EHRH.) FR. var. **dealbata** AUCT.

Common on earth with the last. Granite Falls, July 13, 1899, no. 499.

Not previously reported from Minnesota.

140. **Biatora icterica** MONT.

On earth, rare. Granite Falls, July 11, 1899, no. 398, and July 18, 1899, no. 519.

141. **Biatora rufonigra** TUCK.

On granitic rocks and quartzite, common. New Ulm, July 5, 1899, no. 265. Morton, July 7, 1899, no. 325. Granite Falls, July 12, 1899, no. 454.

142. **Biatora coarctata** (SM., NYL.) TUCK.

On limestone and sandstone, rare. Mankato, June 26, 1899, no. 113. Mankato (Rapidan), June 28, 1899, no. 173.

142*a*. **Biatora coarctata** (SM., NYL.) TUCK. var. **brugeriana**, SCHAER.

On sandstone, locally abundant. Mankato (Minneopa Falls), June 27, 1899, nos. 139, 142, 145 and 146. Mankato (Rapidan), June 29, 1899, nos. 172, 174 and 176.

143. **Biatora uliginosa** (SCHRAD.) FR.

On earth, infrequent. Mankato, June 26, 1899, no. 128. New Ulm, July 5, 1899, no. 250.

144. **Biatora myriocarpoides** (NYL.) TUCK.

On quartzite, locally common. New Ulm, July 5, 1899, no. 300.

145. **Biatora varians** (ACH.) TUCK.

On trees, probably frequent locally. Granite Falls, July 15, 1899, no. 502.

146. **Biatora flexuosa** FR.

On dead cedar, rare. Granite Falls, July 13, 1899, no. 477. Not previously reported from Minnesota.

147. **Biatora hypnophila** (TURN.) TUCK.

On earth and limestone, rare. Mankato, June 23, 1899, no. 36, and June 26, 1899, no. 120.

148. **Biatora nægelii** HEPP.

On trees, infrequent. Granite Falls, July 13, 1899, no. 484, and July 15, 1899, no. 530.

149. **Biatora rubella** (EHRH.) RABENH.

On trees, common locally. Mankato, June 23, 1899, no. 35, and June 26, 1899, no. 130. Mankato (Minneopa Falls), June 27, 1899, no. 138.

150. **Biatora fuscorubella** (HOFFM.) TUCK.

On trees and rocks, common at Mankato, elsewhere rare or infrequent. Mankato, June 23, 1899, no. 29. Mankato (Minneopa Falls), June 27, 1899, no. 141. New Ulm, July 5, 1899, no. 274. Granite Falls, July 15, 1899, nos. 529 and 536.

151. **Biatora suffusa** FR.

On trees, rare. Mankato, June 23, 1899, no. 37. Granite Falls, July 15, 1899, no. 540.

Not previously reported from Minnesota.

152. **Biatora muscorum** (Sw.) Tuck.

On earth, frequent and once on sandstone. Mankato, July 1, 1899, no. 220. New Ulm, July 4, 1899, no. 237. Redwood Falls, July 8, 1899, no. 344. Granite Falls, July 11, 1899, no. 433. Pipestone, July 18, 1899, nos. 590 and 591.

153. **Biatora inundata** Fr.

On limestone and sandstone, common. Mankato, June 22, 1899, no. 24. New Ulm, July 4, 1899, no. 234.

154. **Lecidea enteroleuca** Fr.

On trees, common at Granite Falls. Mankato, June 23, 1899, no. 80, and July 1, 1899, no. 209. New Ulm, July 4, 1899, no. 231. Redwood Falls, July 8, 1899, no. 354. Granite Falls, July 11, 1899, no. 429, July 13, 1899, nos. 476, 479, 485 and 496, and July 14, 1899, no. 516.

155. **Lecidea enteroleuca** Fr. var. **achrista** Sommerf.

On trees, frequent. Granite Falls, July 13, 1899, nos. 471 and 475, and July 15, 1899, no. 546.

156. **Buellia spuria** (Schaer.) Arn.

On granitic rocks, quartzite and pipestone, frequent or common. New Ulm, July 5, 1899, no. 294. Morton, July 7, 1899, no. 324. Granite Falls, July 12, 1899, nos. 445 and 458. Pipestone, July 18, 1899, no. 612.

157. **Buellia alboatra** (Hoffm.) Th. Fr.

On trees, especially *Ulmus*, rare at first locality and more common at second. Mankato, June 22, 1899, no. 15. Granite Falls, July 11, 1899, no. 382, and July 17, 1899, no. 577.

158. **Buellia alboatra** (Hoffm.) Th. Fr. var. **saxicola** Fr.

On limestone, shaded, rare. Mankato, June 22, 1899, no. 16. Not previously reported from Minnesota.

159. **Buellia parasema** (Ach.) Th. Fr.

On trees, infrequent. Mankato, June 23, 1899, no. 34, and June 24, 1899, no. 85. New Ulm, July 3, 1899, no. 224. Granite Falls, July 11, 1899, no. 388.

160. **Buellia myriocarpa** (DC.) Mudd.

On old wood, common or frequent. Mankato, June 22, 1899, no. 20. Mankato (Rapidan), June 28, 1899, no. 184. Granite Falls, July 17, 1899, no. 552.

161. **Buellia pullata** Tuck.

On rocks, frequent. Morton, July 7, 1899, no. 327. North Redwood, July 10, 1899, nos. 365 and 366. Granite Falls, July 11, 1899, no. 405. Pipestone, July 18, 1899, no. 600.

Not previously reported from Minnesota.

162. **Buellia turgescens** (Nyl.) Tuck.

On old boards, rare. Mankato, June 22, 1899, no. 21.

Not previously reported from Minnesota.

163. **Buellia petræa** (Flot., Koerb.) Tuck.

On granite, quartzite and pipestone, abundant. New Ulm, July 5, 1899, nos. 242 and 293. Redwood Falls, July 6, 1899, no. 306. Granite Falls, July 11, 1899, no. 422.

164. **Buellia petræa** (Flot., Koerb.) Tuck. var. **montagnæi** Tuck.

On same rocks as last and even more abundant; however, only a single collection on a bowlder at first locality. Mankato (Rapidan), June 28, 1899, no. 183. Morton, July 7, 1899, nos. 318 and 321. North Redwood, July 10, 1899, no. 362. Granite Falls, July 11, 1899, no. 422a. Pipestone, July 18, 1899, nos. 593 and 620.

165. **Opegrapha varia** (Pers.) Fr.

On trees, abundant. Mankato, June 23, 1899, no. 40, June 26, 1899, no. 110, and July 1, 1899, no. 204. Granite Falls, July 11, 1899, nos. 419 and 421, July 13, 1899, no. 483, and July 15, 1899, nos. 539 and 548.

166. **Opegrapha varia** (Pers.) Fr. var. **pulicaris** (Hoffm.) Fr.

On trees, rare. Granite Falls, July 15, 1899, no. 528.

Not previously reported from Minnesota.

167. **Graphis scripta** (L.) Ach.

On trees, common at Mankato. Mankato, June 22, 1899, no. 14. Granite Falls, July 13, 1899, no. 503.

168. **Graphis scripta** (L.) Ach. var. **recta** (Humb.) Nyl.

On birches, rare. Mankato (Minneopa Falls), June 27, 1899, no. 141a.

169. **Graphis scripta** (L.) Ach. var. **limitata** Ach.

On trees, rare. Mankato, June 22, 1899, no. 23. Granite Falls, July 13, 1899, no 469, and July 15, 1899, no. 538.

170. **Arthonia lecideella** Nyl.

On trees, infrequent. Mankato, June 23, 1899, no. 69.

171. **Arthonia dispersa** (Schrad.) Nyl.

On trees, common. Mankato, June 22, 1899, no. 25, and July 23, 1899, no. 72. Granite Falls, July 13, 1899, no. 490.

172. **Arthonia radiata** (Pers.) Th. Fr.

On trees, infrequent. Mankato, June 23, 1899, no. 70. Granite Falls, July 13, 1899, no. 489, and July 15, 1899, no. 532.

173. **Arthonia punctiformis** Ach.

On maples, rare. Granite Falls, July 15, 1899, no. 341a.

173*a*. **Arthonia** sp.

On trees, rare. Granite Falls, July 15, 1899, no. 541.

With general appearance of *Arthonia dispersa* (Schrad.) Nyl., but the colorless spores are four celled and $\frac{22\text{–}26}{7.5\text{–}8.5}$ mic.

Not previously reported from Minnesota.

174. **Calicium parietinum** Ach.

On old wood, probably rare. Mankato, June 22, 1899, no. 8, and June 24, 1899, no. 87, Redwood Falls, July 8, 1899, no. 326.

175. **Calicium quercinum** Pers.

Collected once only, on cedar. Granite Falls, July 13, 1899, no. 478.

176. **Coniocybe pallida** (Pers.) Fr.

On a large oak, only once collected. Mankato, July 7, 1899, no. 206.

177. **Endocarpon miniatum** (L.) Schaer.

Abundant on limestone bluffs, frequent on granite and rare on quartzite. Mankato, June 23, 1899 no. 46 and June 25, 1899, no. 59. Redwood Falls, July 6, 1899, no. 312. Granite Falls, July 11, 1899, no. 373, and July 13, 1899, no. 474. Pipestone, July 18, 1899, no. 606.

178. **Endocarpon miniatum** (L.) Schaer. var. **complicatum** Schaer.

On substrata noted above and also on pipestone, frequent. Mankato, June 25, 1899, no. 57. New Ulm, July 5, 1899, no. 249. North Redwood, July 10, 1899, no. 363. Granite Falls, July 12, 1899, no. 448, and July 13, 1899, no. 495. Pipestone, July 18, 1899, no. 615, and July 19, 1899, no. 639.

179. **Endocarpon fluviatile** DC.

On rocks frequently wet, infrequent. Morton, July 7, 1899, no. 322. Granite Falls, July 12, 1899, 448a.

180. **Endocarpon arboreum** SCHWEIN.

On trees and shaded rocks, once seen on each. Redwood Falls, July 6, 1899, no. 308, and July 8, 1899, no. 339.

Not previously reported from Minnesota.

181. **Endocarpon hepaticum** ACH.

On earth and sandstone, common. Mankato (Rapidan), June 28, 1899, no. 175. New Ulm, July 4, 1899, no. 235, and July 5, 1899, no. 244. North Redwood, July 10, 1899, no. 364. Granite Falls, July 11, 1899, no. 384. Pipestone, July 18, 1899, no. 623.

182. **Endocarpon pusillum** HEDW.

On limestone bluffs, sandstone, calcareous drift pebbles, and once on earth, common. Mankato, June 23, 1899, no. 39. New Ulm, July 4, 1899, no. 236. Granite Falls, July 12, 1899, no. 442, July 13, 1899, no. 509, and July 14, 1899, no. 526.

183. **Endocarpon pusillum** HEDW. var. **garovaglii** KPH.

On earth and sandstone, frequent. Mankato, July 1, 1899, no. 219. Mankato (Rapidan), June 28, 1899, no. 186. New Ulm, July 5, 1899, no. 282. Morton, July 7, 1899, no. 317. Pipestone, July 18, 1899, no. 616.

184. **Thelocarpon prasinellum** NYL.

On old wood and sandstone, frequent. Mankato, June 22, 1899, no. 6, and June 26, 1899, no. 132.

I cannot bring that on sandstone under any of the rock species, and it seems to belong here.

185. **Staurothele umbrina** (WAHL.) TUCK.

On granite, limestone and quartzite, frequent. Mankato, June 23, 1899, no. 82. Granite Falls, July 11, 1899, no. 412, July 15, 1899, no. 547, and July 17, 1899, no. 566.

186. **Staurothele diffractella** (NYL.) TUCK.

On sandstone, granite, quartzite and calcareous drift pebbles, rare. New Ulm, July 4, 1899, nos. 238 and 240. Granite Falls, July 13, 1899, no. 501, and July 17, 1899, no. 560.

Not previously reported from Minnesota.

187. **Staurothele drummondii** Tuck.

On granite, quartzite and pipestone, common in damp places at Granite Falls and Pipestone. Redwood Falls, July 8, 1899, no. 327. Granite Falls, July 12, 1899, no. 457, July, 13, 1899, no. 494, and July 17, 1899, no. 554. Pipestone, July 18, 1899, nos. 595, 619, 622 and 628.

188. **Verrucaria fuscella** Fr.

On limestone, infrequent. Mankato, June 23, 1899, no. 42.

188*a*. **Verrucaria nigrescens** Pers.

On limestone common and once seen on a granite bowlder. Mankato, June 23, 1899, no. 65, June 24, 1899, no. 96, and June 26, 1899, no. 116.

189. **Verrucaria muralis** Ach.

On limestone in bluffs and drift pebbles, abundant at Mankato. Mankato, June 22, 1899, no. 26. Granite Falls, July 13, 1899, no. 511, and July 14, 1899, no. 525.

190. **Pyrenula punctiformis** (Ach.) Naeg.

On trees, infrequent. Mankato, June 24, 1899, nos. 90 and 94.

191. **Pyrenula punctiformis** (Ach.) Naeg. var. **fallax** Nyl.

On birch, infrequent. Mankato, June 24, 1889, no. 66, and June 26, 1899, no. 109.

192. **Pyrenula gemmata** (Ach.) Naeg.

On trees frequent. Granite Falls, July 14, 1899, no. 513.

Not previously reported from Minnesota.

193. **Pyrenula hyalospora** Nyl.

On trees, probably rare. Mankato, June 23, 1899, no. 32, and June 25, 1899. Granite Falls, July 13, 1899, no. 470.

Not previously reported from Minnesota.

194. **Pyrenula nitida** Ach.

On trees, rare. Mankato, July 1, 1899, no. 211. New Ulm, July 3, 1899, no. 222.

195. **Pyrenula thelena** (Ach.) Tuck.

On birch, common. Mankato (Minneopa Falls), June 27, 1899, no. 140.

196. **Pyrenula cinerella** (Flot.) Tuck.

On trees, infrequent. Mankato (Minneopa Falls), June 27, 1899, no. 143.

Spores reaching 12–16 by 6–8 mic. in one collection. Thus larger than usual American forms.

197. **Pyrenula cinerella** (FLOT.) TUCK. var. **quadriloculata** var. nov.

On birch, probably rare. Mankato, June 26, 1899, no. 129. Mankato (Rapidan), June 28, 1899, no. 163a.

Second time collected in Minnesota and both times from hosts of same genus.

198. **Pyrenula quinqueseptata** (NYL.) TUCK.

On trees, rare. Mankato, July 1, 1899, no. 208.

Spores frequently showing 8 cells, which is not common for the species.

Not previously reported from Minnesota.

199. **Pyrenula leucoplaca** (WALLR.) KBR.

On trees, common. Mankato, June 23, 1899, no. 31. Mankato (Rapidan), June 28, 1899, no. 180. Mankato, July 1, 1899, no. 207. Granite Falls, July 13, 1899, no. 464, and July 15, 1899, nos. 527, 535 and 543.

200. **Pyrenula glabrata** (ACH.) MASS.

On trees, rare. Mankato, June 24, 1899, no. 88.

Not previously reported from Minnesota.

201. **Pyrenula megalospora** sp. nov.

Thallus rather smooth, indeterminate, prominent, gray or grayish white. Apothecia scattered or occasionally aggregated in clusters of two or three, black or brownish black, convex with the ostiole-bearing apex somewhat pointed, semi-immersed or becoming more superficial, .4 to .75 mm. in diameter. Amphithecium white. Paraphyses capillary and very distinct. Asci cylindrical, .25 to .3 mm. in length. Spores colorless, 2-celled, oblong with ends obtuse or somewhat pointed, somewhat constricted at the septum, large for 2-celled spores of the genus (35–60 by 14–21 mic.), 8 in asci, crowded and obliquely uniseriate.

On trees, frequent. Mankato, June 26, 1899, no. 112 and July 1, 1899, no. 209. Granite Falls, July 11, 1899, no. 381 and July 11, 1899, no. 576.

XX. A SYNONYMIC CONSPECTUS OF THE NATIVE AND GARDEN AQUILEGIAS OF NORTH AMERICA.

K. C. Davis.

The name *Aquilegia* (Linn. Sp. Pl. 533, 1753) is probably not from *aquila*, eagle, as commonly given, but from *aquilegus*, water-drawer. The name may have been applied from the supposed power of the roots to extract water from rocks, among which they so often grow. They are commonly called Columbines.

Hardy perennial herbs, mostly with paniculate branches terminated by showy flowers; leaves 1–3 times ternately compound, commonly glaucous; leaflets roundish and obtusely lobed: flowers large, showy, appearing usually in spring or early summer; sepals 5, regular, petaloid; petals concave, produced backward between the sepals forming a hollow spur; stamens numerous; fruit of about 5 many-seeded follicles.

About 30 species are distinct; all of the north temperate regions of the world. Nearly half of these (12) are natives of North America. Most of the native species and varieties are used in American and European gardens, and ten foreign species have already been introduced here. *Aquilegia* furnishes many useful, ornamental forms eminently fitted for choice mixed borders and beds. A good, deep, rather sandy, well drained soil is the best. Seeds sown in pans, in cold frames in March, or open air in April, occasionally bloom the first season, but generally the second. The seed germinates slowly, and the ground should be kept moist on top during this period. The different species should, if possible, be kept some distance apart if pure seed is desired, as the most divers species hybridize directly. They may be propagated by root division but better by seed. Absolutely pure seed is hard to obtain except from the plants in the wild state; and some of the mixed forms are quite inferior to the true species from which they have come. *A. cærulea*, *A. glandulosa*, and *A. vulgaris* are apt to flower only two or three years from the same plant and should be treated as biennials; but *A. vulgaris* may be kept active for a longer period by transplanting.

The latest extended accounts of species in this group are by J. G. Baker, in *Gardener's Chronicle*, 1878; and B. L. Robinson, in *Gray's Synoptical Flora*, 1: 42–45, 1895.

In presenting this and the accompanying paper, I desire to extend thanks to all who have so kindly aided me in my studies of Ranunculaceous genera; particularly I am under obligations to Professor L. H. Bailey for many valuable suggestions at times of greatest need and for placing about me the largest collection of colored plant portraits and the largest garden herbarium in America, and to Professor W. W. Rowlee for placing at my disposal not only the entire collection of herbarium specimens in the department of botany of Cornell University, but also numerous living roots and plants from which to better study vegetative characters.

Key to Species of Aquilegia.

A. Sepals not more than ½ or ¾ inch long; expanded flower 1 or 1½ inches in diameter.
- B. Limb of petal shorter than the sepal.
  - C. Stem-leaves present; stem 1½-to 2½ feet high.
    - D. Spur straight, not knobbed.................. *lactiflora.*
    - DD. Spur knobbed, bent inward............... *oxysepala.*
  - CC. Stem-leaves wanting; stem reduced to a short scape. *Jonesii.*
- BB. Limb of petal about equal to the sepal.
  - C. Leafless or nearly so; stem scapiform......... *elegantula.*
  - CC. Leaves two or more on a stem.
    - D. Plant low, slender (commonly 6–8 inches); spurs incurved.
      - E. Leaves, stems and follicles pubescent. *brevistyla.*
      - EE. Leaves, stems and follicles smooth. *saximontana.*
    - DD. Plant one foot high or more; spurs nearly straight.
      - E. Stamens protruding beyond the petal-limbs.
        - F. Spurs somewhat knobbed..... *Canadensis.*
        - FF. Spurs not knobbed............ *viridiflora.*

EE. Stamens hardly protruding or shorter than petal-limb.

F. Plant finely pubescent above. *Buergeriana.*

FF. Plant glandular-pubescent and viscid above. ....*micrantha.*

AA. Sepals about one inch long; expanded flower about two inches in diameter.

B. Spurs shorter than the petal limb, and incurved....*flabellata.*

BB. Spurs at least as long as the petal-limb.

C. Stamens short, not much protruding.

D. Spurs only slightly curved, not knobbed...*leptoceras.*

DD. Spurs much incurved or coiled.

E. Follicles densely pubescent..............*vulgaris.*

EE. Follicles glabrous........................*Sibirica.*

CC. Stamens long, protruding far beyond the petal-limb.

D. Sepals green, keeled; young fruits winged. *Skinneri.*

DD. Sepals usually yellow or red, not keeled; fruits never winged..*formosa.*

BBB. Spurs very long, often several times as long as petal-limbs.

C. Length of spur about 1 or 1¼ inches...........*pubescens.*

CC. Length of spur about 2 inches...............*chrysantha.*

CCC. Length of spur 4 inches or more...........*longissima.*

AAA. Sepals 1¼ to 1½ or even 2 inches long; expanded flower 2½ to 3 inches in diameter; stamens not protruding.

B. Spurs long and not incurved................................*cærulea.*

BB. Spurs incurved and not longer than the petal-limbs.

C. Follicles few, pubescent................................*alpina.*

CC. Follicles 6–10; densely hairy..................*glandulosa.*

A. lactiflora KAR. & KIR. in Mosc. Bull. **15**: 374. 1841. Stem 1½ feet high, glabrous in the lower part: partial-petioles of root leaves 1½ to 2 inches long, leaflets sessile or short stalked, 1 inch long, many lobes reaching half way down; stem leaves petioled and compound; flowers about 3 on a stem; sepals nearly white, or tinged with blue, over ½ inch long, narrow; petal-limb half as long as the sepal; spur ⅓ inch, slender, nearly straight, not knobbed at tip; stamens equal in length to the limb. June. Altai Mts., Siberia. A desirable species but not much used in gardens.

A. oxysepala TRAUT. & MEYER. in Middend. Reise. Florula Ocho. Phæn. 10. 1856.

Plant 2½ feet high, slightly pubescent above: radical leaves long-petioled, secondary divisions sessile: sepals ovate-lanceolate, much exceeding the petal-limbs in length, which are 6 lines long, white, rounded-truncate; stamens not protruding beyond the petal-limb; spur knobbed, bent inward, shorter than petal-limb: follicles pubescent with styles their own length. June. Eastern Siberia. In 1898 F. H. Horsford said of this: "the first to bloom with me, and one of the most attractive in the list. It is one of the most dwarfed; flowers large, blue, yellow and white: it comes so much before the others that its capsules, as a rule, all fertilize before any of the other species come into flower."

A. Jonesii PERRY, Am. Nat. 8: 211. 1874.

True stem very short or almost wanting, soft-pubescent: tufted root-leaves an inch or two high from the stout, ascending branches of the rootstock; biternately divided partial petioles very short or none; leaflets very crowded: flowers blue; sepals oblong, obtuse, equalling the spurs and twice the length of the petal limbs and head of stamens: follicles glabrous, large, nearly 1 inch long, styles ½ as long; peduncles lengthening to about 3 inches in fruit. July. N. W. Wyoming, Mont., to Brit. Am. Garden & Forest, 9: 365.

A. elegantula GREENE, Pitt. 4: 14. 1899.

Erect, slender, mostly less than a foot high, glabrous except on the inflorescence, the peduncle and exterior of the flowers hirtellous-pubescent; stem scapiform, usually only bracted; radical leaves long-petioled, glabrous beneath: flowers mostly solitary, terminal, small, about 1 inch long, sepals light green, erect; petal-limbs light yellow, erect; spurs straight, longer than the sepals, rather widely inflated above and light scarlet in that part; filaments short; styles exserted. June. Slide Rock Cañon, and in Spruce woods Mt. Hesperus, S. Colo. Described from the original. Type in Greene's Herbarium (†).

A. brevistyla HOOK. Fl. Bor Am. **1**: 24. 1833.

A. vulgaris RICHARDS. in Frankl. Jl. App. 740. 1823, not Linn.

A. vulgaris var. *brevistyla* GRAY, Am. Journ. Sci. Ser. 2, **33**: 242. 1862.

A. Laramiensis A. NELSON Wyom. Exp. Sta. Bull. **28**: 78. 1895–6.

Slender, 6–15 inches high, glandular-pubescent above at least, several flowered: root-leaves biternate, long-petioled, leaflets lobed and crenate; stem-leaves few, lower ones short-petioled: flowers blue with yellowish petals, small, about as broad as long; petals and sepals about equal in length, stamens a little shorter, spurs even shorter and incurved: follicles pubescent, equalling the flower in length, ⅔ inch, becoming erect. May–June. Mts. of Northwest Territory into South Dakota (†).

A. saximontana P. A. RYDBERG ex Robinson, Syn. Fl. 1: 1: 43. 1895.

Stem from a scaly rootstock, less than six inches high: leaves, stems and follicles smooth throughout, otherwise like above. Mts. Colo. (†).

A. Canadensis LINN. Sp. Pl. 533. 1753.

A. variegata MOENCH. Meth. 311. 1794.

A. elegans SALISB. Prod. 374. 1796.

Height 1–2 feet; primary divisions of petioles of root-leaves 1–2 inches, having 3 divisions; 2 or 3 of the stem leaves petioled, biternate: flowers several on a stem; sepals yellowish or tinted on the back with red, about ½ inch long, not reflexing; limb of petals a little shorter, yellowish, truncate; spur ¾ inch long, nearly straight, knobbed at the end, bright red throughout; stamens much protruding: follicles ¾ inch long, with style ½ as long. May–July. Stony banks, etc. East of the Rocky Mts. Introduced 1890. Bot. Mag. 246. Loddiges' Bot. Cab. 888. Meehan's Mo. 5: 21.

Var. **flaviflora** BRITTON Bull. Torr. Club, **15**: 97. 1888.

A. flaviflora TENNEY Am. Nat. **1**: 388. 1867.

A. cærulea var. *flavescens* LAWSON Rev. Canad. Ranun. 75. 1870.

A. flavescens WATS. Bot. King. Exp. 10. 1871.

Flowers a clear yellow. Very pretty. Introduced 1889. Bot. Mag. 6552 B. (as *A. formosa* var. *flavescens*).

Var. **depauperata** n. var.

A. depauperata JONES Contr. West. Bot. No. 8, 1. 1898.

Stems slender; leaves and leaflets smaller than the type: flowers also small, cream colored tinged with blue and green. June. Along streams, and in Provo Cañon, Utah. Collected by M. E. Jones, who has the type (†).

Var. **nana** HORT. Plant 1 foot high or less; flowers like the type.

A. viridiflora PALLAS in Act. Petrop. 260, t. 2. 1779.

Stem 1–1½ feet high, finely pubescent throughout, several flowered: the partial petioles of root-leaves 1–2 inches long; leaflets sessile or the end one shortly stalked, lobes rather narrow and deep; lower stem-leaves petioled, biternate: sepals oblong, obtuse, ascending, greenish, equalling the broad, greenish petal-limb, but not reaching the head of stamens; spur straight, slender, ½ inch long, not knobbed; pubescent follicles as short as their styles. Summer. East Siberia. Not so much used as the following variety.

Var. **atropurpurea** n. var.

A. atropurpurea WILLD. Enum. Hort. Berol. 577. 1813.

A. dahurica PATR. in Deless. Ic. Sel. t. 49. 1820.

Limbs of the petals deep blue or lilac-purple, and the sepals and spur somewhat tinged with the same hue. Bot. Reg. 922.

A. Buergeriana SIEB. & ZUCC. in Abh. Akad. Münch. **4**: II, 183. 1846.

A. atropurpurea MIQUEL. Ann. Mus. Lugd. Bot. **3**: 8. 1867.

One foot high, finely pubescent towards the top; branched to form several heads, bearing 2–3 petioled, biternate leaves; partial-petioles of basal leaves ½–1 inch long, 3 sessile divisions; flowers yellow tinted with purple, 1–1½ inch in diameter; sepals ¾ inch long, acute, spreading; spurs erect, nearly straight, as long as the limb of petal, and about equalling the sepal; head of stamens equal to limb in length: follicles pubescent, ¾ inch long, style half as long. Early. Japan. Brought from St. Petersburg, 1892.

A. micrantha EASTWOOD, Proc. Cal. Acad. Sci. II, **4**: 559. *t. 19.* 1894.

Stem slender, densely glandular-pubescent and viscid on upper parts: leaflets small, cuneate, 3-cleft, with 2–3-lobed segments; partial-petioles of the lateral leaflets short: flowers hardly 1 inch across, yellowish white; sepals nearly ½ inch long, nearly half as broad: petals rather truncate, spur short, straight, or slightly curved. July. Cañons of southeast Utah to Colorado (†).

Var. **ecalcarata** n. var.

A. ecalcarata EASTWOOD in Zoe, 2: 226. 1891; 4: 3. 1893.

Flowers sometimes reddish, fragrant: spurs sometimes reduced to mere sacs, but with intermediated grades to the type form (†).

A. flabellata SIEB. & ZUCC. in Abh. Akad. Münch. 4: II, 183. 1846.

A. vulgaris Thunb. Fl. Jap. 232. 1784. Not Linn.

A. glandulosa Miq. in Ann. Mus. Lugd. Bat. 3: 8. 1867.

Stem 1 to 1½ feet high, few flowered: partial-petioles of root-leaves 1 inch or more, leaflets nearly sessile; stem-leaves large and petioled: flowers bright lilac, or pale purple, or white; sepals 1 inch long, obtuse; limb of petal ½ as long, often white in the lilac flowered form; spur shorter than the limb, slender toward the end, much incurved; stamens not protruding beyond the petal-limbs: follicles glabrous. Summer. Japan. Revue Hort. 109. 1896. Revue Belg. 15: 157.

Var. **nana-alba** HORT., *A. flabellata* var. *flore-albo* HORT. Flowers pure white and the plant dwarfish.

A. leptoceras FISCH. & MEYER. Ind. Hort. Petrop. 4: 33. 1837.

A. brachyceras TURCZ. ex F. & M. Maund. Bot. Gard. no. 755. About 1842.

Stem several flowered, about 1 ft. high: partial-petioles of root-leaves over 1 inch, leaflets sessile; stem-leaves petioled, biternate: flowers violet, with the tips of the sepals greenish, and tips of the short petal-limbs yellow; spur slender, slightly curved, ½ inch long, not knobbed; stamens protruding a little beyond the limbs of the petals: follicles slender, glabrous, nearly 1 inch long. Summer. East Siberia. Bot. Reg. 33: 64. Flor. des Serr. 3: 296. Little used in America.

A. vulgaris LINN. Sp. Pl. 533. 1753.

A. inversa MILL. Gard. Dict. 8 ed. no. 3. 1768.

A. silvestris NECK. Delic. Gallo-Belg. 1: 234. 1768.

A. cornuta GILIB. Fl. Lituan, 2: 286. 1781.

A. versicolor SALISB. Prod. 374. 1796.

A. corniculata VILL. Cat. Hort. Strasb. 250. 1807.

A. stellata HORT. ex Steud. Nom. 1 ed. 61. 1821.

A. elata LEDEB. Ind. Hort. Dorp. Suppl. 41. 1824.

A. atrata KOCH. in Flora, 13: 1. 118. 1830.

A. nigricans BAUMG. Enum. Stirp. Trans. **2**: 104. About 1830.
A. Haenkeana KOCH. Syn. Fl. Germ. 23. 1837.
A. concoler FISCH. ex Steud. Nom. 2 ed. **1**: 115. 1840.
A. ecalcarata HORT. ex Steud. l. c. 115.
A. elegans POPE ex Steud. l. c. 115.
A. sibirica DON ex Steud. l. c. 115.
A. subalpina BOR. Fl. Centr. Fr. 3 ed. **2**: 24. 1840.
A. Bernardi GREN. & GODR. Fl. Fr. **1**: 45. 1848.
A. Transsilvanica SCHUR. Vehr. Siebenb. Ver. Nat. **3**: 94. 1852.
A. sylvestris SCHUR. Vehr. Siebenb. Ver. Nat. **4**: 4. 1853.
A. glaucophylla STEUD. in Flora, **39**: 407. 1856.
A. aggericola JORD. Diagn. **1**: 87. 1860.
A. collina JORD. l. c. 84.
A. dumeticola JORD. l. c. 86.
A. praecox JORD. l. c. 85.
A. paraplesia SCHUR. Enum. Pl. Trans. 28. 1866.
A. corsica SOLIER. ex Nym. Consp. 18. 1878.
A *glaucescens* BAKER, l. c. 203.
A. Karelini BAKER l. c. 76.
A. subscaposa BORHAS in Magyar Tudom. Akad. **12**, IV, 18. 1882.
A. platysepala REICHB. Ic. Fl. Germ. *t. 4730*. About 1886.

Stem 1½–2 feet high, many flowered; finely pubescent throughout: root-leaves with 3 partial-petioles 1½–2 inches long, secondary branches certain, ultimate leaf lobes shallow and roundish, texture firm; lower stem-leaves petioled and biternate: flowers violet to dark purple; sepals ovate, furnished with a claw, acute, 1 inch long, one-half as wide; petal-limb ¾ inch long, equalling the head of stamens; spur about same length, stout, much incurved, knobbed: follicles densely pubescent, 1 inch long, style half as long. Summer. Europe, Siberia, and naturalized in America. Garden 12, p. 288.

Var. **nivea** BAUMG. ex Baker Gard. Chron. II, **10**: 76. 1878. Var. *alba* HORT. Often 2–3 feet high: a great profusion of large, pure white flowers. Several weeks in early spring.

Var. **flore-pleno** HORT. *A. plena* Hort. Flowers much doubled, ranging from pure white to deep blue.

Var. **vervæneana** HORT. Var. *folio-aureis* HORT. Var. *atroviolacea* HORT. Leaves with yellow variegated lines.

Var. **Olympica** BAKER l. c.

A. Olympica BOIES. in Ann. Sc. Nat. II, **16**: 360.

A. blanda LEW. Ill. Hort. **4**: *t. 146.* 1857.

A. Caucasica LEDEB. ex Rupr. Fl. Caus. 32. 1869.

A. Wittmanniana STEV. ex F. & M. l. c.

A fine variety with several large flowers; sepals light lilac or bright purple, 1 inch or more in length, petal-limb white. Revue Hort. 1896, p. 108.

Var. **hybrida** SIMS. Bot. Mag. 1221. 1809.

Much like the last variety, but with stout, lilac-purple spurs as long as the sepals, only slightly incurved. Probably a hybrid of *A. vulgaris* and *A. canadensis*.

A. Sibirica LAM. Encyc. **1**: 150. 1783.

A. bicolor EHRH. Beitr. **7**: 246. 1792.

A. speciosa DC. Syst. **1**: 336. 1818.

A. Garnieriana SWEET Brit. Fl. Gard. II, **5**: *t. 103.* 1833.

Stem 1½–2 feet high, many flowered; stem nearly glabrous throughout: flowers pale or bright lilac-blue; oblong sepals fully 1 inch long, spreading or reflexed a little; petal-limb half as long, equalling the head of stamens, and often white; spur rather stout, ½ inch or more, very much incurved or even coiled: follicles glabrous, 1 inch long, style ⅓ inch. Allied to *A. vulgaris*, differing in the broad, obtuse sepals; spur long and more slender toward the tip, and glabrous follicles. Summer. East Siberia. Sweet's Brit. Fl. Gard. II, *t. 90 & t. 103.*

Var. **spectabilis** BAKER l. c. *A. spectabilis* LEM. Ill. Hort. 403, 1864. A large, bright lilac-flowered variety with petal-limbs tipped with yellow. Amurland.

Var. flore-pleno HORT. *A. bicolor* var. *flore-pleno* HORT. Flowers much doubled by the multiplication of both the limbs and the spurs.

A. Skinneri HOOK. in Bot. Mag. 3919. 1842.

A. Mexicana HOOK., l. c.

Stem 1–2 feet high, many flowered, glabrous: root-leaves long-petioled, with both primary and secondary divisions long, leaflets cordate, 3-parted; several stem-leaves petioled and biternate: sepals, green, keeled, lanceolate, acute, never much spreading, ¾–1 inch long; petal-limb greenish-orange, half as long as sepal; spur bright red, tapering rapidly, over 1 inch long; stamens protruding far beyond the limb: fruit, at least when young, bearing broad, membranous, curled wings; styles 3; after flowering the peduncles become erect. July-Sept. Mts. of New Mex. and Mex. Bot. Mag. 3919. Paxt. Mag. Bot. 10: 199. Flor. des Serr. 1: 17. A handsome plant, requiring a light soil in a sunny border.

Var. flore-pleno HORT. Flowers double. Very fine. Gartenflora 34: 57.

A. formosa FISCH. in DC. Prod. **1**: 50. 1824.

A. artica LOUD. Hort. Brit. 610. 1830.

A. Canadensis var. *formosa* WATS. Bot. King Exp. 10. 1871.

Habit as *A. Canadensis*, root-leaves and stem-leaves like that species, but the flowers are brick red and yellow or wholly yellow, and the sepals are larger, twice as long as the petal-limb, more spreading; spurs somewhat more slender and often shorter. May–Aug. Sitka to Calif. and eastward to the Rockies. Introduced 1881. Bot. Mag. 6552. Flor des Serr. 8: 795.

Var. desertorum JONES Cont. Western. Bot. No. 8, 2. 1898. Stems about one foot high, flexuose: leaves and leaflets rather small: flowers often only about ¾ inch across, nodding: styles slender. In crevices of rocks about springs. Flagstaff, Ariz. (†).

Var. **truncata** BAKER l. c.; JONES Zoe, **4**: 259. 1893.

A. truncata FISCH. & MEY. 1843.

A. Californica LINDL. in Gard. Chron. 836. 1854.

A. eximia VANHOUTTE ex Planch. Fl. des Serr. **12**: 1188. 1857.

Flowers with short thick spurs and very small sepals and petal-limbs. Introduced 1881.

Var. **hybrida** HORT. *A. Californica* var. *hybrida* HORT. Flowers large with scarlet sepals and yellow petals; spurs spreading, long and slender. A supposed hybrid with *A. chrysantha*. Fl. Mag. 1877: 278. Vicks' 1: 33, *f. 2*.

Var. **nana-alba** HORT. Flowers pale, often nearly white; plant not exceeding 1 foot.

Var. **rubra-pleno** HORT. Flowers as in var. *hybrida*, but with several whorls of petal-limbs.

A. pubescens COVILLE Contr. Nat. Herb. **4**: 56, *pl. 1.* 1893. Allied to *A. chrysantha.* Caudex scaly; flowers a very clear yellow; spurs shorter, only 1 to 1½ inches; petal-limbs a third as long as sepals. July. High altitudes Tulare Co., Calif.

A. chrysantha GRAY in Gard. Chron. 1335 and 1501, *f. 304.* 1873.

A. leptoceras var. *chrysantha* HOOK. f. Bot. Mag. 6073. 1873.

A. leptoceras var. *flava* GRAY Pl. Wright **2**: 9. 1852.

Height 3–4 feet; root-leaves with twice 3-branched petioles, leaflets biternate; stem-leaves several, petioled; flowers many on the plant; 2–3 inches across; sepals pale yellow, tinted claret, spreading horizontally; petal-limbs deep yellow, shorter than the sepals and nearly as long as the head of stamens; spur rather straight, very slender, divergent, about 2 inches long, descending when flower is mature; follicles glabrous, 1 inch long; style half as long. May–Aug. New Mex. and Ariz. Introduced 1891. Revue Hort. 1896: 108. Flor. des Serr. 20; 2108. Floral Mag. 1873: 88. Dict. d. Bot. 1: 243. Vicks' 1: 33, *f. 3.*

Var. **aurea** n. var.

A. aurea JUNKA. in Oestr. Bot. Zeitschr. **22**: 174. 1872.

A. Canadensis var. *aurea* ROEZL., Gartenflora 258, *t. 734.* 1872.

Flowers yellow and tinged with red, spurs incurved and shorter than in the type. Gartenflora 21: 734.

Var. **alba-plena** HORT. Var. *grandiflora-alba* HORT. Flowers very pale yellow or nearly white, with two or more whorls of petal-limbs. Introduced. 1889. Vicks' 12: 311.

Var. **nana** HORT. *A. leptoceras* var *lutea* HORT. Like the type, but plant always small, not exceeding 1½ feet.

Var. **Jaeschkani** HORT. About the same height as the last: flowers large, yellow with red spurs. Thought to be a hybrid of *A. chrysantha* and *A. Skinneri*, hence sometimes called *A. Skinneri* var. *hybrida* HORT.

A. longissima GRAY ex Wats. Proc. Am. Acad. **17**: 317. 1881–2.

Tall, somewhat pubescent with silky hairs, or smoothish: root-leaves biternate even in the petioles, leaflets deeply lobed and cut, green above, glaucous beneath; stem-leaves similar, petioled: flowers pale yellow, sepals lanceolate, broadly spreading, an inch or more, the spatulate petals a little shorter, about equalling the head of stamens; spur 4 inches long or more, always hanging, orifice narrow. Distinguished from *A. chrysantha* by longer spur with contracted orifice, by the narrow petals, and by the late season of flowering. Late July to October 1st. Ravines southwest Texas, into Mexico. The seed must be obtained from the wild plants, as those cultivated usually fail to produce seed; hence not much used. Garden & Forest 1: 31.

A. caerulea JAMES, Long Exped. Rocky Mts. **2**: 15. 1826.
A. leptocera NUTT. in Journ. Acad. Phila. **7**: 9. 1834.
A. macrantha HOOK. & ARN. Bot. Beech. Voy. 317, *t. 72*. 1841.

Stem 1½ feet high, finely pubescent above, bearing several flowers: lower stem-leaves large and biternate; basal leaves with long 3-branched petioles; leaflets 3-lobed on secondary stalks: flowers 2 inches across, whitish, but variously tinted with light blue and yellow; sepals often blue, oblong, obtuse, twice as long as the petal-limbs; spurs long, slender, knobbed at the end, rather straight but curving outward: head of stamens equalling the petals: follicles pubescent, 1 inch long; style ⅓ inch. April–July. Lower mountain regions, Montana to New Mexico. Introduced 1891. Bot. Mag. 4407. Garden 16: 198. Meehan's Mo. 6: 61. Vicks' 1: 33, *f. 4*. Bot. Mag. 5477 (as var. *ochroleuca*). Flor. des Serr. 5: 531.

Var. **albiflora** GRAY Syn. Fl. **1**: 1: 44. 1895.

Flowers of the same size but sepals as well as petals almost white. Introduced as var. *alba* HORT. 1883.

Var. **alpina** A. NELSON Wyom. Exp. Sta. Bull. **28**: 78. 1895–6.

Plant smaller than the type; upper leaflets entire; flowers smaller, yellow, spurs rather short.

Var. **calcarea** JONES Proc. Calif. Acad. Sci. II. **5**: 619. 1895.

Plant glandular-pubescent: leaves and leaflets reduced, firm; flowers much smaller than the type; sepals blue-purple; petals reddish. Cannonville, Utah.

Var. **hybrida** HORT. Sepals some shade of blue or pink or mixed, and petals nearly white or yellow. The true form of this is probably *A. cærulea* X *A. chrysantha*. Revue Hort. 1896: 108. Am. Gard. 15: 315.

Var. **flore-pleno** HORT. Flowers longer and very showy; more or less doubled toward the center.

A. alpina LINN. Sp. Pl. 533. 1753.
A. montana STERNB. in Regensb. Denkschr. 2: 60. 1818.
A. Reuteriana REICHB. f. Nym. Consp. 18. 1878.
A. Sternbergii REICHB. Fl. Germ. Excurs. 749. About 1880.
A. alpina var. *superba* HORT.

Stem nearly 1 ft. high, finely pubescent in upper parts; 2–5 flowered: leaves biternate, petioled; partial-petioles of basal leaves 1–2 inches long with 3 nearly sessile leaflets, deeply lobed: expanded flower 1½–2 inches across, blue, rarely pale or white: sepals 1¼ inches long, half as broad, acute; petal-limb half as long as sepal, often white; spur slender, incurved, same length as the limb: head of stamens not protruding: follicles pubescent, 1 inch long, style much shorter. May-June. Switzerland. Bot. Cab. 7: 657. Garden 9: 17.

A. glandulosa FISCH. Hort. Gorenk. 2ed. 48. 1812.

Stem 1 to 1½ feet. high; glandular-pubescent in the upper half; 1–3 flowered: partial-petioles of root leaves 1–2 inches long, each with 3 distinct divisions; leaflet segments narrow and deep: stem-leaves few, bract-like: flowers large, nodding: sepals bright lilac-blue, ovate, acute, almost 1½ inches long and half as broad; petal-limb same color, but tipped and bordered with-creamy white, less than half the length of the sepals, very broad; spur very short, ¼ inch, stout, much incurved; stamens not protruding; follicles 1 inch long, 6–10 in number, densely hairy, with short falcate style. Allied to *A. alpina*, but with shorter spurs, larger flowers, plant taller, greater number of follicles. May–June. Altai Mts. of Siberia. Botanist 5: 219. Floral World 1871: 354. Garden 15: 174. Gartenflora 289, *f. l.*

Var. **jucunda** FISCH. & LALL. Ind. Sem. Petrop. 2. 1840. Flowers rather smaller than in the type; petal-limb white, more truncate at the tip; stamens as long as the limb. A variety with some tendency to double. Bot. Reg. 33: 19. Flor. des Serr. 5: 535.

A. Stuarti HORT. A recorded hybrid of *A. glandulosa* and *A. vulgaris* var. *Olympica*. Flowers very much resemble the latter parent in form of sepals and petals, and the former in shape of spurs and in coloration. May–June. Introduced 1891. Garden 34: 670.

XXI. A SYNONYMIC CONSPECTUS OF THE NATIVE AND GARDEN ACONITUMS OF NORTH AMERICA.

K. C. Davis.

This genus of hardy, ornamental, perennial herbs is much used in borders, and such places, and is commonly called Monkshood. Many species are planted in European gardens; nine only have been thus used in America. The number of species varies from 18 to 80, according to treatment by different authors. They are native in mountainous regions of Europe, temperate Asia, and 7 are found in North America.

Roots tuberous, turnip-shaped, or thick-fibrous: stem tall or long, erect, ascending, or trailing: leaves palmately divided or cleft and cut-lobed: flowers large, irregular, showy; sepals 5, the large upper sepal in shape of a hood or helmet; petals 2–5, small; stamens numerous; carpels 3–5, sessile, many-ovuled, forming follicles when ripened.

The following species do well in any garden soil, but rich soil is preferred. They thrive in open sun, but flowers last longer in shaded places. Aconites should never be planted in, or too near the kitchen garden, or the children's garden, as the roots and some of the flowers contain a deadly poison. Propagated easily by root division.

Besides the Prodromus treatment by A. DeCandolle, in 1824, the only other monographs of the whole genus are by H. G. L. Reichenbach, "Uebersicht der Gattung Aconitum," Leipsic, 1819; "Monograph Generis Aconiti," Leipsic, 1820, folio, 2 vols., and "Illustratio Spec. Aconiti," Leipsic, 1823–7, folio. Reichenbach considered the number of species to be about 80, but many of his names should be treated as synonyms, as they were given to forms varying only slightly from the type.

KEY TO SPECIES OF ACONITUM.

A. Roots tuberous or napiform.
  B. Leaves deeply cut, but not to the base.
    C. Sepals mostly some shade of blue.
      D. Axils of leaves without bulblets.
        E. Beak of helmet prominent or reflexed.
          F. End of beak reflexed.......... *Cammarum.*
          FF. End of beak not reflexed, but prominent.
            G. Stem stout................. *paniculatum.*
            GG. Stem lax............. *Kamtschaticum.*
        EE. Beak of helmet either abruptly pointed or turned inward—not reflexed.
          F. Stem stout, erect................. *Japonicum.*
          FF. Stem slender, sometimes showing a climbing tendency....................... *uncinatum.*
      DD. Axils of leaves with bulblets............ *bulbiferum.*
    CC. Sepals mostly white or yellow bordered with blue.
      D. Stem robust............................... *heterophyllum.*
      DD. Stem slender.............................. *Lycoctonum.*
  BB. Leaves divided to the base.
    C. Helmet higher than wide........................ *variegatum.*
    CC. Helmet, or hood, broad and low.
      D. Follicles rarely varying from four........... *Napellus.*
      DD. Follicles three to five................ *delphinifolium.*
AA. Roots fascicled and elongated, or fibrous.
  B. Stems erect.
    C. Flowers yellowish.................................... *Anthora.*
    CC. Flowers blue to whitish........................ *autumnale.*
  BB. Stems trailing.............. .... *reclinatum.*

A. cammarum LINN. Sp. Pl. 2 ed. 751. 1762.
A. neomontanum WILLD. Sp. Pl. 2: 1236. 1799.
A. bicolor SCHULT. Obs. Bot. 101. 1809.
A. eriostemum DC. Syst. 1: 377. 1818.
A. intermedium DC. l. c. 374.
A. speciosum OTTO, ex DC. Prod. 1: 60. 1824.
A. cernuum BAUMG. ex. Schur. Enum. Pl. Transs. 32. 1866.

REICHENBACH has given the names: *austriacum* TRATT., *Breiterianum*, *decorum*, *exaltatum*, *hamatum*, *hortense* HOPPE., *Ottonianum*, *palmatifidum*, *Sprengelii* RUA, *Storkianum*, *versicolor*.

Stem 3–4 feet high; leaves with short bluntish lobes; flowers purple or blue; panicles or loose spikes few flowered; helmet hemispherical, closed; beak reflexed. July–Sept. Hungary. Introduced 1889. *A. Storkianum* RCHB. Uebers 49, is a form of this with dwarf habit and fewer flowers; roots somewhat fibrous. Bot. Cab. 1991.

A. paniculatum LAM. Fl. Fr. 3: 646. 1778.
A. cernuum WULF. ex Koelle, Spicil. 17. 1786.
A. humile SALISB. Prod. 375. 1796.
A. Wilematianum DELARB. Fl. Anv. 2 ed. 499. 1800.
A. hebegynum DC. Syst. 1: 376. 1818.
A. camarum SCHLEICH. Cat. 5. 1821.
A. neomontanum BAUMG. Enum. Transs. 2: 100. 1816–46.
Forms were named by REICHENBACH: *acuminatum*, *plexicaule* HOPPE & HORN, *galectonum*, *gibbiferum*, *molle*, *parviflorum*, *taxicum*, *reflexum*.

Stem erect, slender, 2–3 feet high; leaves glabrous, rather thin, deeply 3–7 cleft, the divisions obovate, cuneate, incised and dentate; inflorescence pubescent, panicled; flowers blue, few, half as broad as high; helmet with a gibbous arch; beak very prominent and descending, ¼ inch long; open; follicles usually 4, erect, ¼ inch long. Summer. Central Europe. Well figured in Bot. Cab. 810.

A. Noveboracense Gray ex Coville in Bull. Torr. Club, 13: 190. 1886, of South-eastern New York, differs very little, if any, from this.

A. Kamtschaticum PALL. ex Rchb. Uebers. 39. 1819.
A. Napellus THUNB. Fl. Jap. 251. 1784, not Linn.
A. maximum PALL. ex. DC. Syst. 1: 380. 1818 (name only).
A. Fischeri RCHB. Monog. *t. 22.* 1820.
A. Labanskyi RCHB. l. c. *t. 40.*
A. abbreviatum LANGSD. ex DC. Prod. 1: 61. 1824.
A. nasutum HOOK. Fl. Bor. Am. 1: 26. 1833.
A. sinense SIEB. & ZUCC. 1835, not *Chinensis* Siebold.
A. Columbianum NUTT. in Torr. & Gray, Fl. 1: 34. 1838.
A. autumnale LIND. in Journ. Hort. Soc. 2: 77. 1847.
A. arcuatum MAXIM. Fl. Amur. 27. 1859.
A. Californicum Hort.

Roots napiform; stem lax, 2–4 ft. high, pubescent in upper parts: leaves parted or deeply cleft, divisions broadly ovate or cuneate and incised and dentate: flowers pale blue; helmet higher than broad, being ½–¾ in. long; beak often elongated; lower petals small, oblong: follicles erect, oblong, reticulate. Autumn. Of wide geographic range, being found in many parts of Asia, Europe and in the U. S. west of the Rockies. Introduced 1889. Bot. Mag. 7130.

A. Japonicum DECNE. in Rev. Hort. 473. 1851.

Stem erect, 3–4 ft. high, smooth; leaves dark green, shining, petioled, lobes 2–3 times cut, parts blunt and deeply toothed; flowers large, deep blue or violet tinged with red; loose panicles with ascending branches; helmet conical, beak abruptly pointed: follicles 5. July–Sept. Japan. Introduced 1889. Rev. Hort. l. c.

Var. **coeruleum** Hort. Flowers very abundant; panicles shortened.

A. uncinatum LINN. Sp. Pl. 2 ed. 750. 1762.

A. Japonicum THUNB. Fl. Jap. 232. 1784.

A. volubile MUHL. Cat. 52. 1813.

A. scandens MUHL. ex Rchb. Uebers. 38. 1819.

A. variegatum HOOK. f. & THOMS. Fl. Ind. 56. 1858.

Stem slender, 3–5 ft. high; inclined to climb; glabrous below the inflorescence: leaves thick, deeply cut into 3–5 cut-toothed lobes: flowers loosely panicled but crowded at the apex; blue, pubescent, 1 inch broad; helmet erect, nearly as broad as long, obtusely conic, beak or point of helmet turned inward: follicles 3, ½ in. long. June–Sept. Low grounds of Penn., South and West, Japan. Much planted now. Meehan's Mo. 4: 81. Bot. Mag. 1119.

A. bulbiferum HOWELL, Fl. N. W. Am. 1: 25. 1897.

Stems slender, weak and viney, 2–4 ft. long; smooth below, tomentose above: leaves rather small, on short petioles, or the upper sessile, bearing bulblets in their axils, all laciniately cut into acute lobes: sepals pale blue; hood 6–8 lines long. Fruit not seen. In marshes on the eastern slope of the Cascade Mts. near Mt. Hood. Flowering in Sept. Described from the original.(†)

A. heterophyllum WALL. Cat. 4722. 1828. Bot. Mag. 6092. 1874.

A. cordatum ROYLE. Illustr. 56. 1839. not Rafin.

Stem robust, 3 ft. high: lower leaves petioled, upper ones sessile; all dark, large, cordate, coarsely dentate: sepals yellow with violet or blue margins; hood arched, beak rather blunt: follicles 5, erect pubescent. Widely distributed. Himalaya region. Not yet introduced to the American trade, but has recently been used in European gardens because of its striking flowers and leaves. It is used in India as a tonic medicine.

A. Lycoctonum LINN. Sp. Pl. 532. 1753.
A. Pyrenaicum LINN. l. c. 532.
A. altissimum Mill. Gard. Dict. 8 ed. no. 2. 1768.
A. Napellus S. G. GMEL. It **1**: 8. 1768 (?).
A. septentrionale KOELLE. Spicil. 22. 1786.
A. taxicarium SALISB. Prod. 375. 1796.
A. intermedeum Host. Fl. Aust. **2**: 69. 1797.
A. Jacquinianum HOST. l. c. 68.
A. pauciflorum HOST. l. c. 70.
A. ochroleucum WILLD. Sp. Pl. **2**: 1233. 1799.
A. barbatum PATR. ex Pers. Syn. **2**: 83. 1807.
A. galeriflorum STOKES, Bot. Mag. Med. **3**: 216. 1812.
A. Neapolitanum TENORE, Fl. Nap. **1**: 327. 1815.
A. hispidum DC. Syst. **1**: 367. 1818.
A. squarrosum LINN. ex DC. l. c. 368.
A. ochranthum C. A. MEY. in Ledeb. Fl. Alt. **2**: 285. 1830.
A. delphinifolium HORT. ex Steud. Nom. 2 ed. **1**: 18. 1840.
A. ochroleucum HORT. ex Steud. l. c. 19.
A. rubicundum FISCH. ex Steud. l. c. 20.
A. triste FISCH. ex Steud. l. c. 20.
A. excelsum TURCZ. Cat. Baikal. 70. 1842.
A. Hosteanum SCHUR. in Verh. Seibenb. Ver. Naturw. **2**: 177. 1851.
A. Transilvanicum LERCH. ex Schur. in same, **10**: 165. 1859.
Lycoctonum sylvaticum FOURR. in Ann. Soc. Linn. Lyon, n. s. **16**: 326. 1868.
A. umbracticolum SCHUR. in Verh. Naturf. Ver. Bruenn. **15**: 2. 1877.
Names of this accredited to REICHENBACH are: *ægophonum*, *alienum*, *arctophonum*, *australe*, *loreale* SER., *cynoctonum*, *dissectum* TAUSCH., *Gmelini*, *lagoctonum*, *Lamarckii*, *luparia*, *lupicida*, *meloctonum*, *moldavicum*

Hacq., *monanense* Schmidt., *myoctonum*, ***pallidum***, ***perniciosum***, *Phthora*, *ranunculifolium*, ***rectum*** **Bernh.**, ***strictissimum***, *strictum* Willd., ***thelyphonum***, ***therio-phonum***, ***tragoctonum***, *vulparia*, *zooctonum*.

Stem slender, simple, 3–6 feet high; leaves deeply cut into 5–9 lobes; long petioles and under ribs pubescent; flowers yellow or whitish in racemes; helmet a pinched elongated cone; middle sepals usually bearded: follicles usually 3. June–Sept. Europe; Siberia. Bot. Mag. 2570. Gard. Mag. 34: 124.

A. variegatum Linn. Sp. Pl. 532. 1753.
A. alpinum Mill. Gard. Dict. 8 ed. No. 7. 1768.
A. cammarum Jacq. Fl. Aust. 5. *t. 224*. 1775.
A. luridum Salisb. Prod. 375. 1796.
A. volubile Moench. Meth. Suppl. 110. 1802.
A. rostratum Bernh. Ind. Sem. Hort. Erf. 1815.
A. glabrum DC. Syst. 1: 379. 1818.
A. leucanthemum Wender. in Linnaea 5: 53. 1830.
A. nasutum Fisch. ex. G. Don. Gen. Syst. 1: 61. 1831.
A. intermedium Gaud. ex Steud. Nom. 2 ed. 1: 18. 1640.
A. Japonicum Hort. ex Steud. l. c. 18.
A. laciniosum Schleich. ex Steud. l. c. 18.
A. laevigatum Schleich. ex Steud. l. c. 18.
A. uncinatum Hort. ex Steud. l. c. 20.
A. altigaleatum Hayne, Arzn. Gew. 12, *t. 16*. 1845.
A. Burnhardianum Wallr. Sched. Crit. 1: 250, *t. 2*. 1848.

Reichenbach's names for forms of this are: ***bulbiferum***, *flexuosum* Presl., *gracile*, *hamatum*, ***illinitum***, ***italicum*** Tratt., *lasiocarpum*, *macranthum*, *mixtum*, ***rhynchan-thum***.

Erect, 1–6 ft. high: leaves variously divided into usually broad lobes and cut divisions; lower petioles long, others short or none: flowers in a loose panicle or raceme; blue varying to whitish, smoothish; helmet higher than wide, top curved forward; beak pointed horizontal or ascending. July. Europe.

Var. **album** n. var.
A. album Ait. Hort. Kew. 2: 246. 1789.

A pure white form of above type, with roots rather fibrous.

A. Napellus Linn. Sp. Pl. 532. 1753.
A. pyramidale Mill. Gard. Dict. 8 ed. no. 6. 1768.

A. tauricum WULF. in Jacq. Coll. **2**: 112. 1788.

A. neubergense DC. Syst. **1**: 373. 1818.

A. strictum BERNH. ex DC. l. c. 373.

A. laxiflorum SCHL. Cat. 5. 1821.

Napellus vulgaris FOURR. in Ann. Soc. Linn. Lyon, n. s. **16**: 326. 1868.

REICHENBACH has given twenty-four names to forms of this: *acutum*, *ambiguum*, *amœnum*, *Bernhardianum*, *Braunii*, *callibotryon*, *clusianum*, *commutatum*, *firmum*, *formosum*, *Funkianum*, *hians*, *Hoppeanum*, *Koehleri*, *lætum*, *laxiflorum* SCHL., *laxum*, *Mielichhoferi*, *napelloides* SW., *oligocarpum*, *rigidum*, *tennifolium*, *venustum*, *virgatum*.

The best known, as well as the most poisonous species. Stem erect, 3–4 ft. high: leaves divided to the base and cleft 2–3 times into linear lobes: flowers blue in a raceme: peduncles erect, pubescent: helmet broad and low, gaping, smoothish: follicles 4, rarely 3. June–July. Europe, and naturalized here. Gartenflora, 35: 227 (named *A. dissectum* Don.). Regne Végétal, Med. *Pl. 2*. There are very many varieties, differing in shade of flowers, often mottled or lined with white. Var. *album* is nearly white. Var. *bicolor* and Var. *versicolor* are much used in gardens for the large blue-and-white flowers. Bot. Cab. 8: 794 (*versicolor*).

A. delphinifolium DC. Syst. **1**: 380. 1818.

A. Napellus var. *delphinifolium* SERINGE, Mus. Helv. **1**: 159. 1823.

REICHENBACH used for forms of this: *Chamissonianum*, *paradoxum*, *semigaleatum*.

Stem erect, 1–3 feet high, pubescent: leaves deeply parted, and cleft into narrow lobes: flowers blue, large; hood low, beak short; lateral sepals as long and twice as broad as the lower: follicles oblong. British Columbia and Alaska through islands of Behring Strait to Asia.

Var. **ramosum** n. var.

A. ramosum A. NELS. Bull. Torr. Club **26**: 8. 1899.

Much like the type: leaves larger with fewer and longer segments: follicles less pubescent. Professor Nelson considers the pubescence different. Only once found: Limestone Range, Black Hills, Weston Co., Wyom. Co-type at Columbia. (†)

A. Anthora LINN. Sp. Pl. 532. 1753.

A. Pyrenaicum PALL. Reise. **2**: 316. 1776.

A. ochroleucum SALISB. Prod. 375. 1796.

A. Anthorideum DC. Syst. **1**: 366. 1818.

A. Anthorum ST. LAG. in Ann. Soc. Bot. Lyon, **7**: 119. 1880.

REICHENBACH used these names: *Candollei*, *eulophum*, *Jacquini*, *nemerosum*, BIEB., *Pallasii*, *tuberosum* PATR.

Stem erect, 1–2 feet high: leaves parted, usually at the base, parts deeply cut and lobed; more or less hispid beneath, smoothish above; petioles long: flowers in lateral and terminal racemes, pale yellow, often large; inflorescence generally pubescent; spur refracted or hooked; helmet arched but cylindrical at base: follicles 5. June–July. Southern Europe. There are several garden varieties differing in pubescence, size of flower, shape of galea, and width of leaf segments. Bot. Mag. 2654.

A. autumnale REICHB. Monog. *t. 17, f. 2.* 1820.

Stem erect, 3–5 feet high: leaves pedately five lobed: flowers in simple spike becoming a panicle; blue, lilac, or whitish; helmet closed. Sept.–Nov. North China. Introduced about 1870.

A. reclinatum GRAY Am. Journ. Sci. **42**: 34. 1842.

Stem always trailing, 2–5 feet long, nearly glabrous; leaves thin, deeply 3–7 cleft, toothed and cut, lower ones petioled, large, upper ones sessile; flowers white or dull cream-color, pubescent, in loose raceme or simple panicle: helmet twice as high as wide, conic; beak very short; follicles 3, nearly ½ inch long. Summer. Wooded mountain regions of Va. to Ga. (†).

NOTE: The mark (†) indicates that the native species or variety has not yet been introduced to the American trade. Citations at the end of a description are mostly to colored plates.

XXII. A CONTRIBUTION TO THE KNOWLEDGE OF THE FLORA OF SOUTHEASTERN MINNESOTA.

W. A. WHEELER.

The work of the Minnesota Botanical Survey in southeastern Minnesota during the summer of 1899 was carried on with two main purposes in view: first, to collect and preserve plants in formalin for museum and class use, and second, to collect herbarium specimens of the higher seed plants. The work of collection was begun June 1st, and closed August 31st. The catalogue of species is, therefore, very incomplete in its enumeration of the early spring and autumn plants.

District of collection.—The territory in which the collections were made is in the extreme southeastern part of Minnesota, comprising the valleys of Winnebago and Crooked creeks, and the adjoining region near the Mississippi river. Nearly all of this territory is included in an area about twelve miles square, formed by the townships of Mayville and Crooked Creek, on the north, and Winnebago and Jefferson on the south.

Physiography.—The topography of this part of Houston county is not essentially different from that of most of the region south from Red Wing along the Mississippi river to the southern boundary of Minnesota and into Iowa. There is no part of it level or nearly so. It is almost entirely broken by the valleys of the two creeks and their smaller tributaries. The height above the sea level varies from 620 feet at the level of the Mississippi river in the southeastern corner of Jefferson, to 1200 feet in the northwestern corner of Mayville. Crooked creek, from the source of the north fork to its discharge into Bluff slough, is about eleven miles in length. It drains about 65 square miles of territory. The south fork, a branch about three miles long, lies entirely in Mayville. Winnebago creek from the Big spring near its source, to its discharge into Minnesota slough, is about twelve miles in length. There are three small branches, one of which has, within the last decade, become considerably smaller than it formerly was, on account of the drying up of several springs near its source. The amount of water discharged from each of the two main creeks during the summer months is probably not less than 1,500,000 cubic feet per day. Neither creek is very susceptible to changes of season, but either one will rise very rapidly after a sudden heavy rain-fall and return to its usual level in a few hours.

The bluffs are high and steep, and not adapted to cultivation. (Plates XXII. and XXVI.) However, many of the ridges are cultivated and form some of the best farms in this part of the state. The valleys being subject to overflow and the bluffs very steep, by no means the entire area is adapted to cultivation. This condition is very favorable for the collection of native plants.

The valleys are narrow, in no place exceeding a mile in width from the brow of one bluff to the brow of the one opposite.

In taking a view of the ecological groups of the plants inhabiting this region, the territory may, for convenience, be divided into river valley, creek valleys and bluffs.

The river valley is so distinct from the creek valleys that it is almost imperative that it be considered separately. The bluffs along the river vary somewhat from the other bluffs, but not sufficiently to warrant a division into river bluff and creek bluff.

River valley.—In the river valley I include the area from the foot of the bluffs on one side of the river, to the foot of the bluffs on the opposite side, not including any tributaries. Along this stretch of the river, from New Albin, Iowa, to Brownsville, Minnesota, the valley varies from three to five miles in width. The main channel of the river is from one-half a mile to a mile wide. The remainder of the area between the bluffs is formed of islands, sloughs and lakes during most of the year. (Plate XXV., B.) During the spring and early summer the whole area is generally flooded so that collection can be carried on only during the late summer and autumn. The river channel proper is not a fruitful field for the collection of higher plants. The sluggish sloughs, lakes and ponds, however, offer excellent conditions for such collection.

For consideration, the water plants of the river valley may be classified into four main groups: plankton, attached submerged aquatic, attached aquatic plants with natant leaves, and adaptive shore plants.

PLANKTON.

The plants forming this group are those which are not attached to any soil substratum, and so are rarely found in any of the swift-flowing currents, but rather on the surface of protected lakes and ponds and near the high banks of sloughs, where they are protected from rapid currents of wind and water. The plants comprising this group are:

Azolla caroliniana,
Ceratophyllum demersum,
Lemna minor,
Spirodela polyrhiza,
Utricularia vulgaris.

With them are often found plants of *Sagittaria* and *Potamogeton* which have been dislocated from their original position on the soil. They seem to grow nearly as well and bloom nearly as profusely as when attached. In this condition they form part of the plankton, but as they are originally attached and ordinarily remain so, I have not included them in the list of plankton types.

One of the most beautiful and interesting plants of this group is the small heterosporous fern, *Azolla caroliniana.* In the early part of the summer it is green or but slightly red in color and only scattered plants or very small patches can be found. In the later summer and autumn it covers large areas of water with a deep red pure growth or mixed with the duckweeds. In restricted areas it often grows so rapidly late in the summer that it is pushed up from the surface of the water and forms ridges and bunches above the water-level.

ATTACHED SUBMERGED AQUATIC PLANTS.

The floor of some of the very shallow ponds and sloughs is covered with a growth of bassweeds and pondweeds that are entirely immersed. This group contains but few species of the higher plants. The species collected are:

Naias flexilis,
Naias guadalupensis,
Potamogeton pusillus,
Potamogeton zosteraefolius.

Attached aquatic plants with natant leaves.

Castalia tuberosa,
Nelumbo lutea,
Nymphaea advena,
Potamogeton lonchites,
Potamogeton natans,
Sagittaria cuneata.

Nearly every one who has ever visited any of the lakes or rivers of Minnesota is acquainted with at least one representative of this group, the white water-lily, *Castalia tuberosa*. This with the Indian lotus, *Nelumbo lutea*, and the yellow pond-lily, *Nymphæa advena*, all of which are members of the water-lily family, are the most conspicuous and beautiful of our river plants. They cover large areas of shallow water for sometimes a mile or more in extent. It may be of interest to call attention to the methods of adaptation of these plants to their aquatic habitat. The white water-lily and the yellow pond-lily carry their natant leaves on long flexible petioles which allow the leaves to remain upon the surface for variations of several feet in the height of the water. The Indian lotus, however, carries the leaf-blades upon stiff strong petioles some of which are carried up to the water surface and others are raised from one to three feet above the water. (Plate XXV., A.) In case the water rises the natant leaves are destroyed but those that are raised above the surface remain useful to the plant and may in this way be caused to float. The projecting leaves are not conspicuously modified in any way from those that were originally natant.

Both the Indian lotus and the white water-lily are abundant in the sloughs of the Mississippi river at Jefferson. The yellow pond-lily is not so abundant as either of the other two. The *Potamogetons* with floating leaves may be found growing with the water-lilies or in small patches scattered throughout the sloughs. They never cover very large areas to the exclusion of other plants.

Adaptive shore plants.

Alisma plantago-aquatica,
Eleocharis acicularis,
Nelumbo lutea,
Polygonum emersum,
Sagittaria latifolia,
Sagittaria rigida,
Scirpus lacustris.

The plants living on the shores of the lakes and sloughs must adapt themselves to life under the varying conditions in which they may be placed by the rise and fall of the water. During low stages they may be left out of the water entirely and when the water is at its height most of them are nearly or quite submerged. The plants adapting themselves to these conditions might be considered as the *Sagittaria* group, for the two *Sagittarias—latifolia* and *rigida*—are the most abundant shore plants with the possible exception of *Eleocharis acicularis*. *Nelumbo lutea* may often be seen in times of very low water, growing on the muddy banks entirely emersed holding its leaves erect two or three feet above the mud, while the *Castalia* when placed under these conditions lodges its leaves on the mud where they soon die. *Polygonum emersum* covers many banks to the exclusion of other vegetation. It is adapted to living on the exposed mud or in the water but under the latter conditions it always projects its leaf-bearing stems out of the water and keeps the foliage leaves emersed.

WET MEADOWS OF THE RIVER VALLEY.

During a large part of the growing season the wet meadows of the river bottoms are submerged. When they are exposed for a sufficient length of time to become somewhat dry the grasses are generally cut for hay. The plants living under these conditions are mostly coarse grasses and sedges. No trees but willows seem to be able to live upon these meadows and they do not then attain tree size. Some of the plants forming the vegetation of the wet meadows are:

Asclepias incarnata,
Cyperus esculentus,
Eleocharis acicularis,
Elymus virginicus,
Eragrostis hypnoides,
Eupatorium purpureum,
Homalocenchrus virginicus,
Penthorum sedoides,
Scirpus atrovirens,
Scirpus cyperinus,
Sium cicutaefolium,
Sparganium eurycarpum,
Spartina cynosuroides,
Vernonia fasciculata,
Zizania aquatica.

MUD-FLAT VEGETATION.

The mud-flat comprises the highest land of the islands. It is flooded only during the early summer but on account of its growth of timber and shrubs the soil remains wet during the entire year. The largest trees growing anywhere in this region are found on the mud-flats of the Mississippi river.

The plants which form large trees on the islands are:

Acer saccharinum,
Betula nigra,
Fraxinus lanceolata,
Fraxinus nigra,
Gleditsia triacanthos,
Populus deltoides,
Quercus platanoides,
Salix amygdaloides,
Ulmus americana.

The following species do not attain large size, but are either scattered throughout as shrubs or small trees, or form a dense low growth on some of the lower grounds of the mud flat. (Plate XXV., A.)

Cephalanthus occidentalis,
Cornus amonum,
Salix fluviatilis,
Salix nigra.

Three species of woody vines are common throughout the islands. The Virginia creeper, *Parthenocissus quinquefolia*, and wild grape, *Vitis vulpina*, are abundant, covering and in many cases killing large trees. The climbing poison ivy, *Rhus radicans*, is common throughout the most densely wooded parts. It sometimes climbs to a height of twenty-five or thirty feet, and develops a stem from two to three inches in diameter.

During the late summer and autumn the mud-flat throughout is covered with a dense growth of coarse herbs most of which are perennials.

The following herbaceous plants grow on the mud-flat.

Acnida tamariscina,
Apocynum cannabinum,
Arisæma dracontium,
Bidens comosa,
Bidens frondosa,
Bidens lævis,
Cicuta bulbifera,
Helenium autumnale,
Ilysanthes gratioloides,
Lippia lanceolata,
Lobelia cardinalis,
Lycopus americanus,
Lycopus lucidus,
Lycopus rubellus,
Lycopus virginicus,
Lythrum alatum,
Mentha canadensis,
Mimulus ringens,
Onoclea sensibilis,
Polygonum hartwrightii,
Polygonum hydropiperoides,
Polygonum incarnatum,
Polygonum punctatum,
Polygonum virginianum,
Physalis philadelphica,
Physostegia virginiana,
Ranunculus pennsylvanicus,
Scutellaria lateriflora,
Stachys palustris,
Steironema ciliata,
Teucrium canadense,
Urtica gracilis,
Urticastrum divaricatum.

Creek valleys.—The valleys of the creeks present an entirely different aspect from the river valley. The creeks have their own well-defined channels to which they hold almost the year round. High waters never last for any great period of time. Those which are caused by the melting of the snows in the spring generally last from about noon to sun-down while those which are supplied by the heavy June showers generally rise and fall during the night or very early morning. The damage done to vegetation is almost restricted to the floods of the summer months. They come in the season of most rapid growth and destroy a large part of the season's growth with which they come in contact. The areas inundated by these floods are never very extensive compared to those along the river. At most points along the valleys the gradual rise of the land from the creeks to the bluffs is sufficient to prevent the formation of ponds and lakes by the rise of the water. The alluvial soils deposited on the flats do not dry up until late in the summer and so have very little growth besides coarse weeds. They are often cultivated but there is always the danger of the crops being destroyed by high water. Most of the best cultivated fields in the valleys are on the table lands adjacent to the foot of the bluffs. They are generally fertile, are protected from high water and hard winds and are not in a position to wash to any great extent. The steep banks on the north edges of the table lands are generally wooded and bear the richest and greatest variety of plants that can be found anywhere in this region. The table lands are often very sharply marked off from the creek bottoms and steep bluffs. Towards the heads of the creeks the table lands disappear and there is a gradual rise from the creeks to the bluffs.

The water vegetation of the creek valleys is almost entirely limited to the cold water plants of the springs and small streams. There are very few ponds or marshes to contain still water forms.

The vegetation of the land may be divided into that of the wet meadow, moist woods and mesophytic field. The wet meadow is about on a level with the banks of the creeks. It never becomes very dry and on the lower places shows some of the characters of a marsh. The vegetation of the moist woods is well shown on the wooded banks bordering the table lands. Moist woods often cover some of the protected table lands and extend for some distance up the narrow dark ravines. In places where timber covers the flooded areas the vegetation is similar to that of the mud flat on the islands near the river. The vegetation of the open table lands I have called mesophytic field.

Cold spring vegetation.

The valleys of Winnebago and Crooked creeks have a great many springs arising from the bases of the bluffs throughout their whole length but perhaps more numerous at the heads of the creeks than elsewhere. Some of the springs that outlet in low level land occasionally form small cold bogs in which the ordinary cold water plants find very favorable conditions for growth. A large spring near the head of Clear creek, a short branch of Crooked creek contains the greatest abundance of typical cold water plants of any spring visited. The large creeks do not contain much vegetation. The smaller creeks often contain plants similar to those of the cold springs.

The plants characteristic of cold running water are:

Batrachium divaricatum,
Batrachium trichophyllum,
Berula erecta,
Cardamine bulbosa,
Mimulus jamesii,
Philotria canadensis,
Roripa nasturtium,
Veronica americana.

Epilobiums—coloratum and *adenocaulon*—are often found growing in cold spring water but are not peculiar to this locality as they are also found growing in moist soil. None of the spring plants can be called common to large areas, for the conditions necessary for their growth are limited in extent.

Pond vegetation.

There are but very few natural ponds along the creeks. The ponds are generally artificial and as such present a variety of conditions and a corresponding variety of plants. A small natural pond in a bog near Crooked creek contains all it can hold of the yellow pond-lily. (Plate XXVII., B.) This is the only place in which any of the water-lily family were found outside of the sloughs and lakes of the Mississippi river.

Wet meadow vegetation of the creek valleys.

The wet meadows naturally cover a very large part of the creek valleys but under present conditions most of them are used for pasture, or where they can be easily drained for cultivation, though they are of course in constant danger of being flooded. Under these conditions there are but few wet meadows which have retained their original vegetation. Many of them under continual pasturing have grown up to coarse weeds and grasses. The greatest variety of plants is found where the wet meadow has been used as a hay meadow. This offers more nearly the natural conditions for such plants as *Lilium canadense* (Plate XXVII., A). *Habenaria leucophæa*, *Pedicularis lanceolata*, *Saxifraga pennsylvanica*, *Chelone glabra*, *Parnassia caroliniana*, *Onoclea sensibilis* and many others in the list.

The plants which grow in the wet meadows are:

Angelica atropurpurea,
Aster novæ-angliæ,
Aster prenanthoides,
Aster puniceus,
Aster sagittifolius,
Caltha palustris,
Cerastium longipedunculatum,
Chelone glabra,
Cicuta bulbifera,
Cicuta maculata,
Doellingeria umbellata,
Dryopteris thelypteris,
Gentiana crinita,
Gentiana flavida,
Habenaria leucophæa,
Habenaria psycodes,
Lilium canadense,
Lobelia syphilitica,
Lythrum alatum,
Macrocalyx nyctelea,
Mimulus ringens,
Onoclea sensibilis,
Parnassia caroliniana,
Pedicularis lanceolata,
Pimpinella integerrima,
Rudbeckia laciniata,
Rudbeckia triloba,
Rumex acetosella,
Rumex crispus,
Saxifraga pennsylvanica,
Silene alba,
Silphium laciniatum,
Silphium perfoliatum,
Viola obliqua,
Zizia aurea.

Moist woods vegetation.

As previously stated the most typical moist woods vegetation is to be found on the north banks of the table lands. The timber on the banks has much of it been left uncut and offers the very best conditions for the survival of moist woods vegetation. In the list of moist woods plants here given are included only those collected or noted from a single location in Winnebago valley. It is a bank about one-half a mile long bordering on the table land for the greater part of its length. Some of the plants listed do not seem to be typical moist woods plants and in such cases they have probably been driven to the margin of the thicket by the cultivation of the table land on one side and by the high water of the creek bottom on the other. The plants of the moist woods on this bank are:

Acer negundo,
Acer nigrum,
Actæa alba,
Actæa rubra,
Adiantum pedatum,
Adopogon virginicum,
Adoxa moschatellina,
Agastache scrophulariæfolia,
Agrimonia hirsuta,
Amelanchier canadensis,
Anemone quinquefolia,
Apios apios,
Apocynum androsæmifolium,
Aralia nudicaulis,
Aralia racemosa,
Arisæma triphyllum,
Asarum canadense,
Asclepias exaltata,
Asclepias incarnata,
Asclepias syriaca,
Asplenium acrostichoides,
Asplenium filix-fœmina,
Bicuculla cucullaria,
Bidens frondosa,
Bidens comosa,
Botrychium virginianum,
Campanula americana,
Carex rosea,
Carpinus caroliniana,
Caulophyllum thalictroides,
Cerastium longipedunculatum,
Circæa lutetiana,
Clematis virginiana,
Cornus candidissima,
Cornus rotundifolia,
Cornus stolonifera,
Corylus americana,
Cratægus punctata,
Cratægus tomentosa,
Cypripedium hirsutum,
Cystopteris bulbifera,
Deringa canadensis,
Diervilla diervilla,
Epilobium adenocaulon,
Epilobium coloratum,
Equisetum arvense,
Erigeron pulchellus,
Erythronium albidum,
Euonymus atropurpureus,
Eupatorium ageratoides,
Falcata comosa,
Fragaria americana,
Galium aparine,
Galium boreale,
Galium trifidum,
Galium triflorum,
Geranium maculatum,
Geum strictum,
Habenaria bracteata,
Hepatica acuta,
Heracleum lanatum,
Humulus lupulus,
Hydrophyllum virginicum,
Impatiens aurea,
Impatiens biflora,
Juglans cinerea,
Juglans nigra,
Lactuca floridana,
Lathyrus ochroleucus,
Lathyrus venosus,

Leptorchis liliifolia,
Lobelia syphilitica,
Lonicera dioica,
Lonicera sullivantii,
Malus ioensis,
Menispermum canadensis,
Mentha canadensis,
Micrampelis lobata,
Mitella diphylla,
Nabalus albus,
Nepeta cataria,
Onoclea struthiopteris,
Osmunda claytoniana,
Ostrya virginiana,
Oxalis stricta,
Parthenocissus quinquefolia,
Pedicularis canadensis,
Peramium pubescens,
Phlox divaricata,
Phryma leptostachya,
Podophyllum peltatum,
Polemonium reptans,
Polygonatum commutatum,
Polygonum incarnatum,
Polygonum hydropiperoides,
Populus grandidentata,
Populus tremuloides,
Potentilla canadensis,
Prunus americana,
Prunus nigra,
Prunus serotina,
Prunella vulgaris,
Prunus virginiana,
Pteris aquilina,
Pyrola elliptica,
Quercus coccinea,
Quercus macrocarpa,
Quercus rubra,
Quercus velutina,
Ranunculus abortivus,
Ranunculus septentrionalis,
Rhus glabra,
Ribes cynosbati,
Ribes floridum,
Ribes uva-crispa,
Rubus occidentalis,
Rubus villosus,
Rudbeckia laciniata,
Rudbeckia triloba,
Salix amygdaloides,
Salix fluviatilis,
Sambucus canadensis,
Sanicula gregaria,
Sanicula marylandica,
Silene alba,
Smilax herbacea,
Solidago canadensis,
Staphylea trifolia,
Syndesmon thalictroides,
Thalictrum dioicum,
Thalictrum purpurescens,
Tilia americana,
Trillium cernuum,
Trillium erectum,
Triosteum perfoliatum,
Ulmus americana,
Ulmus fulva,
Urtica gracilis,
Urticastrum divaricatum,
Uvularia grandiflora,
Vagnera racemosa,
Viburnum lentago,
Viola pubescens,
Viola obliqua,
Vitis vulpina,
Washingtonia claytoni,
Xanthoxylum americana.

Mesophytic field vegetation.

The mesophytic field vegetation as it exists in the creek valleys to-day is almost entirely a result of cultivation. The table lands which bear the plants of the mesophytic field were formerly almost entirely wooded. To-day they are cleared of timber and used for cultivation. They furnish the best fields for cultivation in the whole district. They are not subject to the overflow of the bottom lands, nor to the drought of the ridges, nor to the washouts of the side-hills. Being so extensively cultivated the plants growing upon them, which are not themselves cultivated, are almost confined to the edges of fields and thickets. Under such conditions a list of plants of this area would have no bearing upon the natural ecological groups.

Bluffs.—The bluffs bordering the river differ from those bordering creek valleys in being steeper and in having many more precipitous cliffs. The brow of the bluff along the river for almost the entire distance bordering the territory covered except where interrupted by branch valleys or ravines is one almost perpendicular limestone cliff, varying from a few feet to a hundred feet in height. Cliffs of this sort are not so common back from the river. The vegetation of the river bluffs differs to some extent from the creek bluffs in its character. Some of the common forest trees of the lowland of the creek valleys, instead of growing on the lowland of the river valley inhabit the foot of the river bluff. The proximity of the river bluff to larger areas of water seems to raise the moisture content of the soil of the river bluff above that of the creek bluff at the same height above water level. The growth then of such a tree as the black walnut at the foot of the river bluff does not show that it grows here under more arid conditions than in the creek valley, but that the same conditions of moisture in the soil are found at a higher level on the river bluff than on the creek bluff.

On all bluffs the vegetation shows the greatest variation with the direction of the slope. Those facing from south to west and receiving the direct rays of the sun from noon to 4 P. M. are generally bare of trees (Plate XXII., B) and shrubs while those facing from north to east are generally thickly wooded (Plate XXVI., B). Ravines with their greater amount of moisture in the soil and greater protection from winds are generally wooded to some extent whatever the direction of the slope (Plate XXII., A and B).

Near the heads of the creeks at the bases of the northern slopes are many moist limestone cliffs with their characteristic abundance of liverworts, mosses and ferns, sometimes almost to the exclusion of the higher seed plants. The moist cliffs bear more of the northern types of plants rare to this region than any one other special area.

The zones of forest vegetation on the bluffs are often very distinctly marked out by a few species. The oaks, *Q. rubra*, *Q. macrocarpa* and *Q. coccinea* extend from the valley to the ridge of the bluff in varying degrees of abundance and thus do not determine the zone. With these, however, are a few species which are limited either to the base or ridge. The aspen and a large-tooth poplar as primary and the ironwood, juneberry and wild crab as secondary species mark out the basal zone of forest and the white oak, white birch and shagbark hickory in varying proportions mark out the ridge forest. Between the zone containing white birch on the ridge and that containing the aspen at the base is a zone which is almost entirely covered with dark-barked trees. Thus the zones are clearly shown by the white bark of the white birch on the ridge and that of the aspen below with the dark-barked trees between.

The vegetation areas of the bluffs may be considered as moist cliffs, wooded slopes and ravines, ridge forests, bare slopes and open ridges, and dry rocks. The plants of the moist cliffs are hydrophytic; those of the wooded slopes and ravines which include a large part of the bluff area are mesophytic; the ridge forests are xerophytic and the bare slope, open ridge and dry rock plants which grow on the most exposed and dry areas in this region are distinctly xerophytic.

Moist cliff vegetation.

This group of plants is one of the most interesting of this region. One is always on the lookout for rare plants to this part of the state from the secluded and often almost inaccessible moist cliff. The short list of plants given here might be said to be almost peculiar to moist cliffs as they are rarely found elsewhere. Others might be named that grow upon moist cliffs, but which are more characteristic of moist woods.

Some of the plants characteristic of moist cliffs are:

Acer spicatum,
Adoxa moschatellina,
Betula lutea,
Circæa alpina,
Dirca palustris,
Pellæa stelleri,
Viburnum opulus.

Vegetation of wooded slopes and ravines.

This group of plants borders and perhaps encroaches upon the moist woods of the valley upon the one hand and the ridge forest upon the other. It covers a large area but does not represent the variety of species that are found in the moist woods of the valley.

Some of the plants of the wooded slopes and ravines are

Asplenium acrostichoides,
Asplenium filix-fœmina,
Castilleja coccinea,
Cypripedium hirsutum,
Cypripedium spectabilis,
Cystopteris fragilis,
Epilobium coloratum,
Erechtites hieracifolia,
Eupatorium ageratoides,
Falcata comosa,
Hieracium umbellatum,
Hieracium scabrum,
Hypericum maculata,
Hypericum majus,
Lilium umbellatum,
Lobelia cordifolia,
Lobelia inflata,
Onoclea struthiopteris,
Osmunda claytoniana,
Panax quinquefolia,
Pedicularis canadensis,
Polygonatum commutatum,
Pteris aquilina,
Rubus occidentalis,
Rubus villosus,
Silene stellata,
Smilax herbacea,
Smilax hispida.

Ridge forest vegetation.

Most of the woods upon the ridges are rather open and therefore present somewhat xerophytic conditions. The principal forest trees of the ridges are those which have been previously mentioned, *i. e.*, *Betula papyrifera*, *Hicoria ovata*, *Quercus alba* and *Quercus macrocarpa*. Scattered trees of other kinds are found on special areas. On the point of a bluff near the village of Freeburg, several trees of *Gymnocladus dioicus* were found in one of the most exposed locations that it could obtain. This is a very unusual location for this tree. *Prunus virginiana*, *Juniperus virginiana*, *Tilia americana* and *Celtis occidentalis* quite frequently grow near or on the rocky summits of the bluffs but do not cover large areas.

Bare slope and open ridge vegetation.

The soil of the southern slope and open ridge is generally largely formed of sand and broken limestone. It becomes very dry early in the summer, and then appears almost bare of vegetation except where it is broken by scattered junipers (Plate XXI., A) or patches of *Rhus glabra*.

Some of the plants characteristic of the bare slope and open ridge are:

Acerates viridiflora,
Asclepias verticillata,
Aster sericeus,
Bouteloua curtipendula,
Bouteloua hirsuta,
Coreopsis palmata,
Cyperus filiculmis,
Cyperus houghtoni,
Cyperus schweinitzii,
Draba caroliniana,
Elymus canadensis,
Helianthus occidentalis,
Euphorbia heterophylla,
Hieracium canadense,
Juniperus communis,
Juniperus sabina,
Kœleria cristata,
Kuhnistera candida,
Kuhnistera purpurea,
Lacinaria cylindracea,
Lacinaria scariosa,
Lappula lappula,
Linum sulcatum,
Lobelia spicata,
Oxalis violacea,
Polygala verticillata,
Polygonum tenue,
Pulsatilla hirsutissima,
Ratibida columnaris,
Rhus glabra,
Rhus radicans,
Silene antirrhina,
Valeriana edulis,
Viola pedata,
Viola pedatifida.

Dry rock vegetation (Plate XXI., B).

The rock plants and sand plants do not in many places form distinct groups. The sand of the bluffs nearly always contains considerable broken limestone and thus furnishes conditions favorable to the growth of limestone plants. *Pellæa atropurpurea* and *Camptosorus rhizophyllus* seem to be the only ones that are restricted to the bare limestone. The former prefers dryer and more exposed locations than the latter.

The characteristic plants of dry rocks are:

Betula papyrifera,
Campanula rotundifolia,
Camptosorus rhizophyllus,
Cystopteris bulbifera,
Juniperus communis,
Pellæa atropurpurea,
Valeriana edulis,
Zygadenus elegans.

Results of the survey.—The botanical survey of this part of the state was undertaken with a great deal of interest by the collectors. Never before has this region been explored for the purpose of botanical collection. Great opportunities were therefore offered in the search for species, which may have made this corner of the state the northern limit of their range and for those which may have strayed down the Mississippi river from their native home at its headwaters. With such possibilities in view the collectors were not disappointed with the results.

As a result of the survey 578 species of plants were collected, 26 of which are Pteridophyta, 5 Archispermæ, 87 Monocotyledons and 460 Dicotyledons.

In the catalogue of species are reported the following plants which either have not been previously reported from Minnesota or have been reported without any known authentic collection. The specimens have been placed in the Herbarium of the University.

Allionia linearis,†
Asplenium angustifolium,
Bidens comosa,*
Carex torta,
Cratægus macracantha,
Falcata pitcheri,*
Gleditsia triacanthos,
Helianthus atrorubens,
Hieracium umbellatum,†
Meibomia illinoensis,
Naias guadalupensis,
Prunus nigra,
Quercus prinoides,
Rudbeckia triloba,
Sanicula trifoliata,
Senecio plattensis.*

The following plants collected are of great interest as rare plants in the state or in this part of the state.

Arctostaphylos uva-ursi,
Asclepias obtusifolia,
Azolla caroliniana,
Betula lenta,
Carex lurida,
Cheilanthes gracilis,
Cratægus punctata,
Cyperus houghtoni,
Dasystoma grandiflora,
Dryopteris goldieana,
Gaura biennis,
Hamamelis virginiana,
Hydrocotyle americana,
Juniperus sabina,
Lactuca ludoviciana,
Lactuca sagittifolia,
Meibomia dillenii,
Polygonum tenue,
Polygonum virginianum,
Quercus platanoides,

* Previously collected but not reported from Minnesota.

† Previously reported from incorrect determinations or from general distribution ranges given in large manuals without authentic collection.

Sanicula gregaria,
Sagittaria cuneata,
Solidago erecta,
Thalesia uniflora,
Woodsia oregana.

CATALOG OF SPECIES COLLECTED.

The following catalog of plants contains only those collected by Mr. H. L. Lyon and the writer in the southeastern part of Houston county. With the exception of about ten species which were collected in Brownsville, they were all gathered in the townships of Mayville, Crooked Creek, Winnebago and Jefferson.

The determinations were almost entirely made by the collectors, each determining the plants of his own collection. The determinations of the species of *Physalis* were kindly made by Mr. P. A. Rydberg, of Columbia University, and those of *Quercus prinoides*, *velutina*, *coccinea* and *rubra*, and *Betula lenta* by Professor C. S. Sargent.

The nomenclature is that of Britton and Brown's Illustrated Flora of the Northern United States and Canada.

PTERIDOPHYTA.

OPHIOGLOSSACEÆ.

Botrychium virginianum (L.) Sw. Schrad. Journ. Bot. 2: 111. 1800.
Coll.: Lyon 38, Winnebago; 207, Mayville. June, July.
Infrequent, rich woods and shady banks.

OSMUNDACEÆ.

Osmunda claytoniana L. Sp. Pl. 1066. 1753.
Coll.: Lyon 43, Winnebago. June.
Common, shady hillsides and ravines.

POLYPODIACEÆ.

Onoclea sensibilis L. Sp. Pl. 1062. 1753.
Coll.: Lyon 326, Jefferson. Aug.
Common, wet meadows and river bottoms.

Onoclea struthiopteris (L.) Hoffm. Deutsch. Fl. 2: 11. 1795.
Coll.: Lyon 79, Winnebago; 208, Mayville. June, July.
Common, moist thickets and river bottoms.

Woodsia oregana D. C. EATON, Can. Nat. **2**: 90. 1865.
Coll.: Lyon 306, Jefferson. Aug.
Rare and local, on brow of river bluff. The only previous collection reported from Minnesota is that from Stillwater by Miss Field. There are no previously collected specimens from Minnesota in the Herbarium of the University.

Cystopteris bulbifera (L.) BERNH. Schrad. Neues Journ. Bot. **1**: Part 2, 26. 1806.
Coll.: Lyon 57, Winnebago. June.
Common on shaded rocks and limestone ledges.

Cystopteris fragilis (L.) BERNH. Schrad. Neues Journ. Bot. **1**: Part 2, 27. 1806.
Coll.: Lyon 221, Mayville. July.
Frequent in deep woods.

Dryopteris thelypteris (L.) A. GRAY, Man. 630. 1848.
Coll.: Lyon 461, Brownsville. Aug.
Common in swamps and wet meadows along Wild Cat creek.

Dryopteris goldieana (HOOK.) A. GRAY, Man. 631. 1848.
Coll.: Lyon 203, 222, Mayville. July.
Rare and local, deep rich woods. The only previous authentic collection in Minnesota is that of Leiberg at Minneopa falls, Blue Earth County.

Dryopteris spinulosa (RETZ.) KUNTZE, Rev. Gen. Pl. 813. 1891.
Coll.: Lyon 253½, Mayville. July.
Rare and local, deep rich woods.

Camptosorus rhizophyllus (L.) LINK, Hort. Berol. **2**: 69. 1833.
Coll.: Lyon 32, 65, Winnebago. June.
Infrequent or rare, limestone ledges and boulders.

Asplenium angustifolium MICHX. Fl. Bor. Am. **2**: 265. 1803.
Coll.: Lyon 204, 224, Mayville. July.
Rare, deep rich woods. Not previously reported from Minnesota.

Asplenium acrostichoides SW. Schrad. Journ. Bot. **2**: 54. 1800.
Coll.: Lyon 206, 223, Mayville; 318, Jefferson. July Aug.
Frequent, rich woods and moist thickets.

Asplenium filix-fœmina (L.) BERNH. Schrad. Neues Journ. Bot. **1**: Part 2, 26. 1806.

Coll.: Lyon 205, 220, Mayville. July.

Common woods and thickets.

Adiantum pedatum L. Sp. Pl. 1095. 1753.

Coll.: Lyon 45, Winnebago. June.

Common, woods and shady banks.

Pteris aquilina L. Sp. Pl. 1075. 1753.

Coll.: Lyon 42, Winnebago. June.

Common, hillsides and cut-over timber lands.

Pellæa stelleri (S. G. GMEL.) WATT, Can. Fil. No. 2. 1869–70.

Coll.: Lyon 77, Winnebago. June.

Infrequent, moist limestone ledges.

Pellæa atropurpurea (L.) LINK, Fil. Hort. Berol. 59. 1841.

Coll.: Lyon 30, Winnebago. June.

Frequent, dry limestone cliffs and boulders.

Cheilanthes gracilis (FEÉ) METT. Abh. Senck. Nat. Gesell. **3**: (reprint 36). 1859.

Coll.: Lyon 299, 305, Jefferson. Aug.

Rare and local, dry limestone cliff. There is no previous authentic collection of this from Minnesota in the University Herbarium. Sandberg's collection from Vermillion lake made in 1885 and reported as this species should be *Cheilanthes lanosa* (Michx.) Watt. which has not previously been reported from Minnesota.

Polypodium vulgare L. Sp. Pl. 1085. 1753.

Coll.: Lyon 76, Winnebago. June.

Local on limestone ledge.

SALVINIACEÆ.

Azolla caroliniana WILLD. Sp. Pl. **5**: 541. 1810.

Coll.: Lyon 276, Allamakee Co., Iowa; 298, 444, Jefferson. Aug.

Abundant on sloughs and lakes of the Mississippi.

EQUISETACEÆ.

Equisetum arvense L. Sp. Pl. 1061. 1753.

Coll.: Lyon 102, Winnebago. June.

Frequent, meadows and pastures.

Equisetum pratense Ehrh. Hanov. Mag. 138. 1784.
Coll.: Lyon 29, Winnebago. June.
Frequent in light shaded soil.

Equisetum hyemale L. Sp. Pl. 1062. 1753.
Coll.: Lyon 415, Winnebago. Aug.
Common.

Equisetum lævigatum A. Br.; Engelm. Amer. Journn. Sci. 46: 87. 1844.
Coll.: Lyon 18, Winnebago. June.
Local, moist meadows.

SELAGINELLACEÆ.

Selaginella rupestris (L.) Spring. in Mart. Fl. Bras. **1**: Part 2, 118. 1840.
Coll.: Lyon 78, Winnebago. June.
Infrequent, dry rocks.

SPERMATOPHYTA.

ARCHISPERMÆ.

PINACEÆ.

Pinus strobus L. Sp. Pl. 1001. 1753.
Coll.: Wheeler 166, 254, Winnebago. June.
Local on bluffs along Winnebago and Crooked Creeks.

Juniperus communis L. Sp. Pl. 1040. 1753.
Coll.: Wheeler 108, Winnebago; 213, Jefferson; 349, Crooked Creek. June, July.
Common on dry bluffs. (Plates XXI., A and B, XXIV., B.)

Juniperus virginiana L. Sp. Pl. 1039. 1753.
Coll.: Wheeler 158, 169, Winnebago. June.
Frequent on dry bluffs.

Juniperus sabina L. Sp. Pl. 1039. 1753.
Coll.: Wheeler 214, Jefferson. June.
Rare and local on dry bluffs. No previous collection reported from this part of the state. This is about the most southern point of collection for this species in the United States according to Britton and Brown.

TAXACEÆ.

Taxus minor (MICHX.) BRITTON, Mem. Torr. Club, **5**: 19. 1893.

Coll.: Wheeler 289, Crooked Creek; 317, Mayville; 433, Jefferson. July.

Infrequent, generally on dry limestone ridges, occasionally in woods. Not previously reported from the southern part of the state.

METASPERMÆ.

TYPHACEÆ.

Typha latifolia L. Sp. Pl. 971. 1753.

Coll.: Wheeler 266, Winnebago. June.

SPARGANIACEÆ.

Sparganium eurycarpum ENGELM. in A. Gray, Man. Ed. 2, 430. 1856.

Coll.: Wheeler 423, Jefferson. July.

NAIADACEÆ.

Potamogeton natans L. Sp. Pl. 126. 1753.

Coll.: Wheeler 460, Jefferson. Aug.

Potamogeton lonchites TUCKERM. Am. Journ. Sci (II.) **6**: 226. 1848.

Coll.: Wheeler 395, 488, Jefferson. Aug.

Potamogeton zosteræfolius SCHUM. Enum. Pl. Saell. 50. 1801.

Coll.: Wheeler 462, 490, 497, Jefferson. Aug.

Potamogeton pusillus L. Sp. Pl. 127. 1753.

Coll.: Wheeler 461, Jefferson. Aug.

Naias flexilis (WILLD.) ROST. & SCHMIDT, Fl. Sed. 384. 1824.

Coll.: Lyon 329, Jefferson. Aug.

Naias guadalupensis (SPRENG.) MORONG, Mem. Torr. Club, **3**: Part 2, 60. 1893.

Coll.: Lyon 443, Jefferson. Aug.

Not previously reported from Minnesota. Sloughs and lakes of the Mississippi river.

ALISMACEÆ.

Alisma plantago-aquatica L. Sp. Pl. 342. 1753.

Coll.: Lyon 384, Jefferson. Aug.

Sagittaria latifolia WILLD. Sp. Pl. **4**: 409. 1806.
Coll.: Wheeler 123, Winnebago; 304. Crooked Creek; 492, Jefferson. June–Aug.

Sagittaria cuneata SHELDON, Bull. Torr. Club, **20**: 283. *pl. 159*. 1893.
Coll.: Wheeler 491, 495, Jefferson. Aug.
Not previously reported from this part of the state or the Mississippi river. Frequent in sloughs.

Sagittaria rigida PURSH, Fl. Am. Sept. 397. 1814.
Coll.: Wheeler 486, Jefferson. Aug.

Sagittaria cristata ENGELM.; Arthur, Proc. Davenport Acad. **4**: 29. 1882.
Coll.: Lyon 481, Jefferson. Aug.

VALLISNERIACEÆ.

Philotria canadensis (MICHX.) BRITTON, Science (II.) **2**: 5. 1895.
Coll.: Lyon 174, Winnebago. July.

GRAMINEÆ.

Andropogon furcatus MUHL.; Willd. Sp. Pl. **4**: 919. 1806.
Coll.: Wheeler 404, Jefferson. July.

Chrysopogon avenaceus (MICHX.) BENTH. Journ. Linn. Soc. **19**: 73. 1881.
Coll.: Lyon 354, Jefferson. Aug.

Syntherisma sanguinalis (L.) NASH, Bull. Torr. Club, **22**: 420. 1895.
Coll.: Wheeler 424, Jefferson. July.

Panicum crus-galli L. Sp. Pl. 56. 1753.
Coll.: Wheeler 420, Lyon 478, Jefferson. July, Aug.

Panicum porterianum NASH, Bull. Torr. Club **22**: 420. 1895.
Coll.: Wheeler 388, Jefferson. July.

Panicum scribnerianum NASH, Bull. Torr. Club, **22**: 421. 1895.
Coll.: Wheeler 182, Winnebago. June.

Panicum virgatum L. Sp. Pl. 59. 1753.
Coll.: Wheeler 421, Jefferson. July.

Panicum capillare L. Sp. Pl. 58. 1753.
Coll.: Lyon 477, Jefferson. Aug.

Cenchrus tribuloides L. Sp. Pl. 1050. 1753.
Coll.: Lyon 287, Jefferson. July.

Zizania aquatica L. Sp. Pl. 991. 1753.
Coll.: Wheeler 523, Jefferson. Aug.

Homalocenchrus virginicus (WILLD.) BRITTON, Trans. N. Y. Acad. Sci. 9: 14. 1889.
Coll.: Wheeler 564, Jefferson. Aug.

Spartina cynosuroides (L.) WILLD. Enum. 80. 1809.
Coll.: Wheeler 426, Jefferson. July.

Bouteloua hirsuta LAG. Var. Cienc. y Litter 2: Part 4, 141. 1805.
Coll.: Wheeler 347, Crooked Creek; Lyon 291, Jefferson. July.

Bouteloua curtipendula (MICHX.) TORR. Emory's Rep. 153. 1848.
Coll.: Wheeler 362, Crooked Creek. July.

Eragrostis hypnoides (LAM.) B.S.P. Prel. Cat. N. Y. 69. 1888.
Coll.: Wheeler 524, Jefferson. Aug.

Kœleria cristata (L.) PERS. Syn. 1: 97. 1805.
Coll.: Lyon 113, Winnebago. June.

Panicularia americana (TORR.) MACM. Met. Minn. 81. 1892.
Coll.: Lyon 59, Winnebago. June.

Bromus ciliatus L. Sp. Pl. 76. 1753.
Coll.: Lyon 414, Winnebago. Aug.

Bromus kalmii A. GRAY, Man. 600. 1848.
Coll.: Lyon 259, Jefferson. July.

Bromus secalinus L. Sp. Pl. 76. 1753.
Coll.: Lyon 184, Winnebago. July.

Elymus virginicus L. Sp. Pl. 84. 1753.
Coll.: Wheeler 418, Jefferson. July.

Elymus canadensis L. Sp. Pl. 83. 1753.
Coll.: Wheeler 292, Mayville. July.

CYPERACEÆ.

Cyperus schweinitzii TORR. Ann. Lyc. N. Y. 3: 276. 1836.
Coll.: Lyon 375, Jefferson. Aug.

Cyperus esculentus L. Sp. Pl. 45. 1753.
Coll.: Wheeler 526, Jefferson. Aug.

Cyperus filiculmis VAHL, Enum. **2**: 328. 1806.
Coll.: Wheeler 348, Crooked Creek. July.

Cyperus houghtoni TORR. Ann. Lyc. N. Y. **3**: 277. 1836.
Coll.: Wheeler 346, Crooked Creek. July.

The only previous collection known from Minnesota is that of Holzinger, St. Croix River, Minn. Britton reports this collection in the Bull. Torr. Club, **18**: 368. 1891.

The collection from Crooked Creek was made from the summit of a very dry sandy hill. Both *C. houghtoni* and *C. schweinitzii* grow in sand but the former probably grows in the drier locality of the two.

Eleocharis acicularis (L.) R. & S. Syst. **2**: 154. 1817.
Coll.: Wheeler 527, Jefferson. Aug.

Scirpus lacustris L. Sp. Pl. 48. 1753.
Coll.: Wheeler 148, Winnebago. June.

Scirpus atrovirens MUHL. Gram. 43. 1817.
Coll.: Wheeler 267, Winnebago. June.

Scirpus cyperinus (L.) KUNTH, Enum. **2**: 170. 1837.
Coll.: Lyon 168, Crooked Creek; Wheeler 425, Jefferson. June, July.

Carex lupulina MUHL.; Schk. Riedg. **2**: 54. *f. 123*. 1806.
Coll.: Lyon 280, Jefferson. July.

Carex lurida WAHL. Kongl. Acad. Handl. (II.) **24**: 153. 1803.
Coll.: Wheeler 142, Winnebago. June.

No Minnesota specimens in the Herbarium of the University. Previously collected at Lake Itasca, Sandberg No. 1180.

Carex hystricina MUHL.; Willd. Sp. Pl. **4**: 282. 1805.
Coll.: Wheeler 119, Winnebago. June.

Carex filiformis L. Sp. Pl. 976. 1753.
Coll.: Wheeler 121, Winnebago. June.

Carex torta BOOTT; Tuckerm. Enum. Meth. 11. 1843.
Coll.: Lyon 60, Winnebago. June.

Not previously reported from Minnesota. The nearest point of previous collection, as shown by the Herbarium of the University, is Winnebago county, Wisconsin.

Carex stipata MUHL.; Willd. Sp. Pl. **4**: 233. 1805.
Coll.: Wheeler 116, Winnebago. June.

Carex vulpinoidea Michx. Fl. Bor. Am. **2**: 169. 1803.
Coll.: Wheeler 144, Winnebago. June.

Carex rosea Schk. Riedgr. Nachtr. 15. *f. 179.* 1806.
Coll.: Wheeler 11, 143, Winnebago. June.

Carex tribuloides Wahl. Kongl. Vet. Acad. Handl. (II.) **24**: 145. 1803.
Coll.: Wheeler 118, Winnebago. June.

Carex cristatella Britton, Br. & Br. Ill. Fl. N. U. S. & Can. **1**: 357. *f. 865.* 1896.
Coll.: Wheeler 197, Winnebago. June.

ARACEÆ.

Arisæma triphyllum (L.) Torr. Fl. N. Y. **2**: 239. 1843.
Coll.: Lyon 31, Winnebago. June.

Arisæma dracontium (L.) Schott, Melet. **1**: 17. 1832.
Coll.: Lyon 239, Mayville; 248. Crooked Creek. July.
The only previous collections reported from Minnesota are Manning, Lake Pepin and Holzinger, Winona. Frequent in moist woods along the Mississippi River.

LEMNACEÆ.

Spirodela polyrhiza (L.) Schleid. Linnæa, **13**: 392. 1839.
Coll.: Wheeler 113, Winnebago. June.

Lemna minor L. Sp. Pl. 970. 1753.
Coll.: Wheeler 112, Winnebago. June.

COMMELINACEÆ.

Tradescantia virginiana L. Sp. Pl. 288. 1753.
Coll.: Lyon 45, Winnebago. June.

Tradescantia reflexa Raf. Atl. Journ. 150. 1832.
Coll.: Wheeler 410, Jefferson. July.
Not previously reported from Minnesota.

JUNCACEÆ.

Juncus effusus L. Sp. Pl. 326. 1753.
Coll.: Lyon 58, Winnebago. June.

Juncus tenuis Willd. Sp. Pl. **2**: 214. 1799.
Coll.: Lyon 73, Winnebago. June.

MELANTHACEÆ.

Zygadenus elegans Pursh, Fl. Am. Sept. 241. 1814.
Coll.: Lyon 49, Winnebago. June.

Uvularia grandiflora J. E. SMITH, Ex. Bot. 1: 99. *pl. 51.* 1804–5.
Coll.: Lyon 91, Winnebago. June.

LILIACEÆ.

Lilium umbellatum PURSH, Fl. Am. Sept. 229. 1814.
Coll.: Lyon 146, Winnebago. June.
All previous collections of this species from Minnesota have been reported as *L. philadelphicum* L. The latter species so far as known has not been collected in Minnesota.

Lilium canadense L. Sp. Pl. 303. 1753.
Coll.: Lyon 199, Crooked Creek. July.
Common, moist meadows. (Plate XXVII., A.)

Erythronium albidum NUTT. Gen. 1: 223. 1818.
Coll.: Herb. Wheeler 1, Winnebago. May.

CONVALLARIACEÆ.

Vagnera racemosa (L.) MORONG, Mem. Torr. Club, **5**: 114. 1894.
Coll.: Wheeler 67, Winnebago. June.

Vagnera stellata (L.) MORONG, Mem. Torr. Club, **5**: 114. 1894.
Coll.: Wheeler 97, Winnebago. June.

Unifolium canadense (DESF.) GREENE, Bull. Torr. Club, **15**: 287. 1888.
Coll.: Wheeler 98, Winnebago. June.

Polygonatum commutatum (R. & S.) DIETR.; Otto & Dietr. Gartenz. **3**: 222. 1835.
Coll.: Wheeler 78, 184, Winnebago; 570, Jefferson; Lyon 166, Crooked Creek. June, Aug.

Trillium erectum L. Sp. Pl. 340. 1753.
Coll.: Lyon 17, Winnebago. June.

Trillium cernuum L. Sp. Pl. 339. 1753.
Coll.: Herb. Wheeler 2, Winnebago. May.

SMILACEÆ.

Smilax herbacea L. Sp. Pl. 1030. 1753.
Coll.: Wheeler 376, Mayville; 467, Jefferson. July, Aug.

Smilax hispida Muhl.; Torr. Fl. N. Y. 2: 302. 1843.
Coll.: Wheeler 372, Crooked Creek; Lyon 258, Jefferson. July.

AMARYLLIDACEÆ.

Hypoxis hirsuta (L.) Coville, Mem. Torr. Club, **5**: 118. 1894.
Coll.: Wheeler 91, Winnebago. June.

DIOSCOREACEÆ.

Dioscorea villosa L. Sp. Pl. 1033. 1753.
Coll.: Wheeler 322, Mayville; 364, Crooked Creek. July.

IRIDACEÆ.

Iris versicolor L. Sp. Pl. 39. 1753.
Coll.: Lyon 362, Jefferson. Aug.

Sisyrinchium angustifolium Mill. Gard. Dict. Ed. 7. 1759.
Coll.: Lyon 75, Winnebago. June.

ORCHIDACEÆ.

Cypripedium reginæ Walt. Fl. Car. 222. 1788.
Coll.: Wheeler 192, Winnebago. June.

Cypripedium candidum Willd. Sp. Pl. **4**: 142. 1805.
Coll.: Wheeler 99, Winnebago. June.

Cypripedium hirsutum Mill. Gard. Dict. Ed. 8, No. 3. 1768.
Coll.: Wheeler 66, 82, Winnebago. June.

Orchis spectabilis L. Sp. Pl. 943. 1753.
Coll.: Herb. Wheeler 8, Winnebago. June.

Habenaria bracteata (Willd.) R. Br. in Ait. Hort. Kew, Ed. 2, **5**: 192. 1813.
Coll.: Wheeler 106, Winnebago. June.

Habenaria leucophæa (Nutt.) A. Gray, Man. Ed. 5, 502. 1867.
Coll.: Wheeler 299, Crooked Creek. July.

Habenaria psycodes (L.) A. Gray, Am. Journ. Sci. **38**: 310. 1840.
Coll.: Wheeler 386, Jefferson. July.

Peramium pubescens (Willd.) MacM. Met. Minn. 172. 1892.
Coll.: Lyon 100, Winnebago. June.

Leptorchis liliifolia (L.) KUNTZE, Rev. Gen. Pl. 671. 1891.
Coll.: Wheeler 107, 168, 195, Winnebago; 350, Crooked Creek; 391, Jefferson. June, July.

JUGLANDACEÆ.

Juglans nigra L. Sp. Pl. 997. 1753.
Coll.: Lyon 243, Crooked Creek. July.

Juglans cinerea L. Sp. Pl. Ed. 2, 1415. 1763.
Coll.: Lyon 62, 108, Winnebago. June.

Hicoria minima (MARSH.) BRITTON, Bull. Torr. Club, **15**: 284. 1888.
Coll.: Lyon 149, Winnebago; 238, 239, Mayville; 475, Jefferson. June, Aug.

Hicoria ovata (MILL) BRITTON, Bull. Torr. Club, **15**: 283. 1888.
Coll.: Lyon 71, Winnebago; 474, Jefferson. June, Aug.

SALICACEÆ.

Populus alba L. Sp. Pl. 1034. 1753.
Coll.: Lyon 159, Winnebago. June.

Populus balsamifera candicans (AIT.) A. GRAY, Man. Ed. 2, 419. 1856.
Coll.: Lyon 156, Winnebago. June.

Populus grandidentata MICHX. Fl. Bor. Am. **2**: 243. 1803.
Coll.: Lyon 64, Winnebago. June.

Populus tremuloides MICHX. Fl. Bor. Am. **2**: 243. 1803.
Coll.: Lyon 88, Winnebago. June.

Populus deltoides MARSH, Arb. Am. 106. 1785.
Coll.: Lyon 125, Winnebago. June.

Salix nigra MARSH, Arb. Am. 139. 1785.
Coll.: Wheeler 265, Winnebago. June.

Salix amygdaloides ANDERS. Ofv. Handl. Vet. Akad. **1858**: 114. 1858.
Coll.: Wheeler 137, Winnebago. June.

Salix lucida MUHL. Neue Scrift. Ges. Nat. Fr. Berlin, **4**: 239. *pl. 6. f. 7.* 1803.
Coll.: Wheeler 138½, Winnebago; 232, Crooked Creek. June, July.

Salix fluviatilis Nutt. Sylva, 1: 73. 1842.
Coll.: Wheeler 136, Winnebago; 333, Crooked Creek. June, July.

Salix bebbiana Sarg. Gard. & For. 8: 463. 1895.
Coll.: Wheeler 343, Crooked Creek. July.

Salix humilis Marsh, Arb. Am. 140. 1785.
Coll.: Wheeler 181, Winnebago. June.

Salix discolor Muhl. Neue Schrift. Ges. Nat. Fr. Berlin, 4: 234. *pl. 6. f. 1.* 1803.
Coll.: Wheeler 138, Winnebago; 334, Crooked Creek. June, July.

BETULACEÆ.

Carpinus caroliniana Walt. Fl. Car. 236. 1788.
Coll.: Lyon 56, Winnebago. June.

Ostrya virginiana (Mill.) Willd. Sp. Pl. 4: 469. 1805.
Coll.: Wheeler 200, Winnebago. June.

Corylus americana Walt. Fl. Car. 236. 1788.
Coll.: Wheeler 22, Winnebago. June.

Corylus rostrata Ait. Hort. Kew. 3: 364. 1789.
Coll.: Wheeler 223, Winnebago; 275, Crooked Creek. June.
Not previously collected from southern part of state. Local on bluffs.

Betula papyrifera Marsh. Art. Am. 19. 1785.
Coll.: Wheeler 215, Jefferson. June.
Common, dry ridges. (Plates XXIII., A and XXIV., B.)

Betula nigra L. Sp. Pl. 982. 1753.
Coll.: Wheeler 553, Jefferson. Aug.
Common in the lowlands of the Mississippi River.

Betula lenta L. Sp. Pl. 983. 1753.
Coll.: Wheeler 165, Winnebago. June.
Not previously collected in the southern part of the state. Rare.

Betula lutea Michx. f. Arb. Am. 2: 152. *pl. 5.* 1812.
Coll.: Wheeler 199, Winnebago; 271, Crooked Creek; 325, Mayville. June, July.
Frequent in moist locations along Winnebago and Crooked creeks.

Betula pumila L. Mant. 124. 1767.
Coll.; Wheeler 272, Crooked Creek. June.
Local along Crooked creek, forming large thickets in wet meadows.

Alnus incana (L.) WILLD. Sp. Pl. 4: 335. 1805.
Coll.: Wheeler 617, Brownsville. Aug.
Local at mouth of Wild Cat creek.

FAGACEÆ.

Quercus rubra L. Sp. Pl. 996. 1753.
Coll.: Wheeler 640, 641, Jefferson. Aug.
Common throughout.

Quercus coccinea WANG. Amer. 44. *pl. 4. f. 9.* 1787.
Coll.: Wheeler 644, 645, Jefferson. Aug.
Common throughout.

Quercus velutina LAM. Encycl. 1: 721. 1783.
Coll.: Wheeler 642, 643, Jefferson. Aug.
Prof. Sargent writes about 643: "Collection 643, which I call *Q. velutina*, differs from that species as it usually occurs by the much smaller less tomentose buds; the acorns, however, are clearly from *Q. velutina*. I frequently have seen specimens of this same form from the region immediately west of the Great Lakes. It appears sometimes as if it might be a hybrid between *Q. velutina* and *Q. coccinea* but its occurrence is too frequent and its distribution too wide to admit of this supposition. With the present state of our knowledge I can but refer it to *Q. velutina*."
Q. velutina does not seem to be nearly so common in this region as *Q. coccinea*.

Quercus alba L. Sp. Pl. 996. 1753.
Coll.: Wheeler 638, Jefferson. Aug.
Common on ridges of bluffs throughout.

Quercus macrocarpa MICHX. Hist. Chen. Am. 2. *pl. 23.* 1801.
Coll.: Wheeler 639, Jefferson. Aug.
Common throughout.

Quercus platanoides (LAM.) SUDW. Rep. Secy. Agric. 1892: 327. 1893.
Coll.: Wheeler 366, Crooked Creek; 456, 538, 654, Jefferson. July, Aug.

No previous collection reported from Minnesota. Reported by Garrison as frequent at several points near the headwaters of the Mississippi. Frequent on the lowlands of the Mississippi in Jefferson and Crooked Creek townships and in Allamakee Co., Iowa.

Quercus prinoides WILLD. Neue Schrift. Ges. Nat. Fr. Berlin, **3**: 397. 1801.

Coll.: Wheeler 360, Crooked Creek. July.

Not previously reported from Minnesota. Whether this is the species reported by Lapham as *Q. castanea* Willd. cannot be ascertained as there are no specimens from Lapham's collection in the Herbarium of the University.

The specimens were collected from two trees on the side of a bluff in section 19, township 102 N., range 4 W.

ULMACEÆ.

Ulmus americana L. Sp. Pl. 226. 1753.

Coll.: Wheeler 24, Winnebago. June.

Ulmus racemosa THOMAS, Am. Jour. Sci. **19**: 170. 1831.

Coll.: Wheeler 315, Mayville. July.

Infrequent on lowland near Crooked creek.

Ulmus fulva MICHX. Fl. Bor. Am. **1**: 172. 1803.

Coll.: Wheeler 23, Winnebago. June.

Celtis occidentalis L. Sp. Pl. 1044. 1753.

Coll.: Wheeler 240, Winnebago; 278, Crooked Creek; Lyon 374, Jefferson. June, Aug.

MORACEÆ.

Morus rubra L. Sp. Pl. 986. 1753.

Coll.: Lyon 368, Jefferson. Aug.

Infrequent along Mississippi river.

Humulus lupulus L. Sp. Pl. 1028. 1753.

Coll.: Lyon 312, Winnebago. Aug.

Cannabis sativa L. Sp. Pl. 1027. 1753.

Coll.: Lyon 282, Jefferson. Aug.

URTICACEÆ.

Urtica gracilis AIT. Hort. Kew. **3**: 341. 1789.

Coll.: Lyon 126, Winnebago. June.

Urticastrum divaricatum (L.) KUNTZE, Rev. Gen. Pl. 635. 1891.
Coll.: Lyon 117, Winnebago; 358, Jefferson. June, Aug.

Adicea pumila (L.) RAF.; Torr. Fl. N. Y. **2**: 223. As synonym. 1843.
Coll.: Wheeler 327, Mayville; 653, Jefferson. July, Aug.

Parietaria pennsylvanica MUHL.; Willd. Sp. Pl. **4**; 955. 1806.
Coll.: Lyon 191, Crooked Creek. July.

SANTALACEÆ.

Comandra umbellata (L.) NUTT. Gen. **1**: 157. 1818.
Coll.: Lyon 90, Winnebago. June.

ARISTOLOCHIACEÆ.

Asarum canadense L. Sp. Pl. 442. 1753.
Coll.: Wheeler 57, Winnebago. June.

POLYGONACEÆ.

Rumex acetosella L. Sp. Pl. 338. 1753.
Coll.: Lyon 130, Winnebago. June.

Rumex crispus L. Sp. Pl. 335. 1753.
Coll.: Lyon 127, 158, Winnebago. June.

Polygonum hartwrightii A. GRAY, Proc. Am. Acad, **8**: 294. 1870.
Coll.: Wheeler 606, Brownsville. Aug.

Polygonum emersum (MICHX.) BRITTON, Trans. N. Y. Acad. Sci. **8**: 73. 1879.
Coll.: Wheeler 394, 458, Jefferson. July, Aug.

Polygonum incarnatum ELL. Bot. S. C. & Ga. **1**: 456. 1817.
Coll.: Wheeler 419, Jefferson. July.

Polyonum hydropiper L. Sp. Pl. 361. 1753.
Coll.: Lyon 494, Jefferson. Aug.

Polygonum punctatum ELL. Bot. S. C. & Ga. **1**: 455. 1817.
Coll.: Wheeler 537, 539, Jefferson. Aug.

Polygonum orientale L. Sp. Pl. 362. 1753.
Coll.: Wheeler 448, Jefferson. Aug.

Polygonum virginianum L. Sp. Pl. 360. 1753.
Coll.: Wheeler 580, Jefferson; 597.
Crooked Creek. Aug.
The only previous collections from Minnesota are Sheldon, Madison lake and Sheldon, Zumbrota. Infrequent in moist woods along Mississippi river.

Polygonum ramosissimum Michx. Fl. Bor. Am. **1**: 237. 1803.
Coll.: Wheeler 514, Winnebago; 531, Jefferson. Aug.

Polygonum tenue Michx. Fl. Bor. Am. **1**: 238. 1803.
Coll.: Wheeler, 351, Crooked Creek. July.
The only previous authentic collection from Minnesota is Moyer, Montevideo. Infrequent on dry sandy ridges.

Polygonum convolvulus L. Sp. Pl. 364. 1753.
Coll.: Wheeler 451, Jefferson. Aug.

Polygonum scandens L. Sp. Pl. 364. 1753.
Coll.: Wheeler 646, Jefferson. Aug.

Polygonum sagittatum L. Sp. Pl. 363. 1753.
Coll.: Wheeler 387, Jefferson. July.

CHENOPODIACEÆ.

Chenopodium botrys L. Sp. Pl. 219. 1753.
Coll.: Lyon 472, Jefferson. Aug.

Salsola tragus L. Sp. Pl. Ed. 2, 322. 1762.
Coll.: Lyon 396, Jefferson. Aug.

AMARANTHACEÆ.

Amaranthus retroflexus L. Sp. Pl. 991. 1753.
Coll.: Wheeler 598, Crooked Creek. Aug.

Amaranthus blitoides S. Wats. Proc. Am. Acad. **12**: 273. 1877.
Coll.: Wheeler 452, Jefferson. Aug.

Acnida tamariscina (Nutt.) Wood, Bot. & Fl. 289. 1873.
Coll.: Wheeler 522, 547, Jefferson. Aug.

Froelichia floridana (Nutt.) Moq. in DC. Prodr. **13**: Part 2, 420. 1849.
Coll.: Lyon 304, 325, Jefferson. Aug.

NYCTAGINACEÆ.

Allionia nyctaginea Michx. Fl. Bor. Am. **1**: 100. 1803.
Coll.: Wheeler 76, Lyon 40, Winnebago. June.

Allionia linearis Pursh, Fl. Am. Sept. 728. 1814.
Coll.: Wheeler 392, Jefferson. July.
Not previously collected in Minnesota. Collections Oestlund 155 and Herrick 256, Minneapolis, in the Herbarium of the University and reported in Metaspermæ of Minnesota Valley as *A. linearis* Pursh ? should be *A. hirsuta* Pursh.

AIZOACEÆ.

Mollugo verticillata L. Sp. Pl. 89. 1753.
Coll.: Lyon 279, 302, Jefferson. July, Aug.

CARYOPHYLLACEÆ.

Silene stellata (L.) Ait. f. Hort. Kew. **3**: 84. 1811.
Coll.: Lyon 254, Wheeler 508, Winnebago. July, Aug.

Silene alba Muhl. Cat. 45. 1813.
Coll.: Lyon 164, Winnebago. June.
The only previous collections from Minnesota are from Goodhue and Winona counties. Frequent along Winnebago and Crooked creeks.

Silene antirrhina L. Sp. Pl. 419. 1753.
Coll.: Wheeler 171, Winnebago. June.

Cerastium longipedunculatum Muhl. Cat. 46. 1813.
Coll.: Lyon 8, Winnebago. June.

NYMPHÆACEÆ.

Nymphæa advena Soland. in Ait. Hort. Kew. **2**: 226. 1789.
Coll.: Wheeler 307, Crooked Creek; 454, Jefferson. July, Aug. (Plate XXVII., B.)

Castalia tuberosa (Paine) Greene, Bull. Torr. Club, **15**: 84. 1888.
Coll.: Wheeler 293, 439, 496, Jefferson. July, Aug.

Nelumbo lutea (Willd.) Pers. Syn. **1**: 92. 1805.
Coll.: Wheeler 409, 494, Jefferson. July, Aug.
Abundant in the sloughs of the Mississippi river at Jefferson. (Plate XXV., A.)

CERATOPHYLLACEÆ.

Ceratophyllum demersum L. Sp. Pl. 992. 1753.
Coll.: Lyon 367, 480, Jefferson. Aug.
Common in the sloughs of the Mississippi river at Jefferson and Crooked Creek.

RANUNCULACEÆ.

Caltha palustris L. Sp. Pl. 558. 1753.
Coll.: Lyon 244, Crooked Creek. July.

Actæa rubra (AIT.) WILLD. Enum. 561. 1809.
Coll.: Lyon 450, Jefferson. Aug.

Actæa alba (L.) MILL. Gard. Dict. Ed. 8, No. 2. 1768.
Coll.: Lyon 16, Winnebago. June.

Aquilegia canadensis L. Sp. Pl. 533. 1753.
Coll.: Wheeler 84, Winnebago. June.

Anemone virginiana L. Sp. Pl. 540. 1753.
Coll.: Lyon 9, Winnebago; 245, Crooked Creek. June, July.

Anemone canadensis L. Syst. Ed. 12, **3**: App. 231. 1768.
Coll.: Lyon 286½, Jefferson. July.

Anemone quinquefolia L. Sp. Pl. 541. 1753.
Coll.: Herb. Wheeler 4, Winnebago. May.

Hepatica acuta (PURSH) BRITTON, Ann. N. Y. Acad. Sci. **6**: 234. 1891.
Coll.: Wheeler 134, Winnebago. June.

Syndesmon thalictroides (L.) HOFFMG. Flora, **15**: Part 2, Intell. Bl. 4, 34. 1832.
Coll.: Wheeler 36, Winnebago. June.

Pulsatilla hirsutissima (PURSH) BRITTON, Am. N. Y. Acad. Sci. **6**: 217. 1891.
Coll.: Wheeler 73, Winnebago. June.

Clematis virginiana L. Amoen. Acad. **4**: 275. 1759.
Coll.: Wheeler 194, Winnebago; 355, Crooked Creek. June, July.

Atragene americana SIMS, Bot. Mag. *pl. 887*. 1806.
Coll.: Wheeler 259, Winnebago; 320, Mayville. June, July.

Ranunculus delphinifolius TORR.; Eaton, Man. Ed. 2, 395. 1818.
Coll.: Lyon 201, Crooked Creek. July.

Ranunculus abortivus L. Sp. Pl. 551. 1753.
Coll.: Wheeler 15, Winnebago. June.

Ranunculus pennsylvanicus L. f. Suppl. 272. 1781.
Coll.: Lyon 364, 378, Jefferson. Aug.

Ranunculus septentrionalis Poir. in Lam. Encycl. 6: 125. 1804.
Coll.: Wheeler 6, Winnebago. June.

Batrachium trichophyllum (Chaix) Bosch, Prodr. Fl. Bot. 5. 1850.
Coll.: Lyon 67, Winnebago. June.

Batrachium divaricatum (Schrank) Wimm. Fl. Schles. 1841.
Coll.: Lyon 219, Mayville. July.

Thalictrum dioicum L. Sp. Pl. 545. 1753.
Coll.: Herb. Wheeler 13, Winnebago. June.

Thalictrum purpurascens L. Sp. Pl. 546. 1753.
Coll.: Lyon 99, Winnebago. June.

BERBERIDACEÆ.

Caulophyllum thalictroides (L.) Michx. Fl. Bor. Am. 1: 205. 1803.
Coll.: Lyon 92, Winnebago. June.

Podophyllum peltatum L. Sp. Pl. 505. 1753.
Coll.: Lyon 1, Wheeler 157, Winnebago. June.

MENISPERMACEÆ.

Menispermum canadense L. Sp. Pl. 340. 1753.
Coll.: Wheeler 188, Winnebago. June.

PAPAVERACEÆ.

Sanguinaria canadensis L. Sp. Pl. 505. 1753.
Coll.: Lyon 169, Crooked Creek. June.

Bicuculla cucullaria (L.) Millsp. Bull. W. Va. Agric. Exp. Sta. 2: 327. 1892.
Coll.: Wheeler 12, Winnebago. June.

CRUCIFERÆ.

Lepidium apetalum Willd. Sp. Pl. 3: 439. 1801.
Coll.: Lyon 123, Winnebago. June.

Sisymbrium officinale (L.) Scop. Fl. Cam. Ed. 2, 2: 26. 1772.
Coll.: Lyon 422, Winnebago. Aug.

Sisymbrium altissimum L. Sp. Pl. 659. 1753.
Coll.: Lyon 273, Wheeler 481, Jefferson. July, Aug.

Brassica nigra (L.) Koch, in Rœhl, Deutsche Fl. Ed. 3, 4: 713. 1833.
Coll.: Lyon 233, Crooked Creek. July.

Brassica arvensis (L.) B.S.P. Prel. Cat. N. Y. 1888.
Coll.: Lyon 86, Winnebago. June.

Roripa palustris (L.) BESS. Enum. 27. 1821.
Coll.: Lyon 200, Crooked Creek. July.

Roripa nasturtium (L.) RUSBY, Mem. Torr. Club, **3**: Part 3, 5. 1893.
Coll.: Lyon 89, Winnebago. June.

Cardamine bulbosa (SCHREB.) B.S.P. Prel. Cat. N. Y. 4. 1888.
Coll.: Wheeler 167, Winnebago. June.

Bursa bursa-pastoris (L.) BRITTON, Mem. Torr. Club, **5**: 172. 1894.
Coll.: Lyon 120, Winnebago. June.

Camelina sativa (L.) CRANTZ, Stirp. Austr. **1**: 18. 1762.
Coll.: Lyon 213, Mayville. July.

Draba caroliniana WALT. Fl. Car. 174. 1788.
Coll.: Lyon 47, Winnebago. June.

Arabis lævigata (MUHL.) POIR. in Lam. Encycl. Suppl. **1**: 411. 1810.
Coll.: Wheeler 154, Winnebago. June.

Arabis canadensis L. Sp. Pl. 665. 1753.
Coll.: Lyon 111, Winnebago; 212, Crooked Creek. June, July.

Arabis glabra (L.) BERNH. Verz. Syst. Erf. 195. 1800.
Coll.: Lyon 122, Winnebago; 227, Mayville. June, July.

Erysimum cheiranthoides L. Sp. Pl. 661. 1753.
Coll.: Lyon 187, Crooked Creek; 226, Mayville. July.

CAPPARIDACEÆ.

Polanisia graveolens RAF. Am. Journ. Sci. **1**: 378. 1819.
Coll.: Lyon 277, Jefferson. July.

CRASSULACEÆ.

Penthorum sedoides L. Sp. Pl. 432. 1753.
Coll.: Wheeler 384, Jefferson. July.

SAXIFRAGACEÆ.

Saxifraga pennsylvanica L. Sp. Pl. 399. 1753.
Coll.: Wheeler 180, Winnebago. June.

Heuchera hispida PURSH, Fl. Am. Sept. 188. 1814.
Coll.: Wheeler 83, Winnebago. June.

Mitella diphylla L. Sp. Pl. 406. 1753.
Coll.: Wheeler 40, Winnebago. June.

Parnassia caroliniana MICHX. Fl. Bor. Am. **1**: 184. 1803.
Coll.: Wheeler 587, Crooked Creek; 629, Brownsville. Aug.

GROSSULARIACEÆ.

Ribes cynosbati L. Sp. Pl. 202. 1753.
Coll.: Wheeler 77, 110, Winnebago. June.

Ribes uva-crispa L. Sp. Pl. 201. 1753.
Coll.: Wheeler 30, 75, 248, Winnebago. June.
Frequently adventive in open woods throughout.

Ribes floridum L'HER. Stirp. Nov. **1**: 4. 1784.
Coll.: Lyon 82, Winnebago. June.

HAMAMELIDACEÆ.

Hamamelis virginiana L. Sp. Pl. 124. 1753.
Coll.: Wheeler 150, Winnebago. June.
Reported from southeastern Winona County. No Minnesota specimens in the Herbarium of the University. Local on north side of bluff in section 22 of Winnebago.

ROSACEÆ.

Opulaster opulifolius (L.) KUNTZE, Rev. Gen. Pl. 949. 1891.
Coll.: Lyon 33, 103, Winnebago. June.

Spiræa salicifolia L. Sp. Pl. 489. 1753.
Coll.: Lyon 438, 464, Jefferson. Aug.

Rubus occidentalis L. Sp. Pl. 493. 1753.
Coll.: Lyon 55, Winnebago; Wheeler 453, Jefferson. June, Aug.

Rubus villosus AIT. Hort. Kew. **2**: 210. 1789.
Coll.: Wheeler 105, Lyon 296, Winnebago. June, Aug.

Rubus canadensis L. Sp. Pl. 494. 1753.
Coll.: Wheeler 396, Jefferson. July.

Fragaria americana (PORTER) BRITTON, Bull. Torr. Club, **19**: 222. 1892.
Coll.: Wheeler 135, Winnebago. June.

Potentilla arguta PURSH, Fl. Am. Sept. 736. 1814.
Coll.: Lyon 247, Crooked Creek. July.

Potentilla monspeliensis L. Sp. Pl. 499. 1753.
Coll.: Lyon 439, Jefferson. Aug.

Potentilla canadensis L. Sp. Pl. 498. 1753.
Coll.: Wheeler 86, Winnebago. June.

Geum canadense Jacq. Hort. Vind. **2**: 82. *pl. 175.* 1772.
Coll.: Lyon 209, Crooked Creek. July.

Geum strictum Ait. Hort. Kew. **2**: 217. 1789.
Coll.: Wheeler 277, Lyon 195, Crooked Creek. June, July.

Agrimonia hirsuta (Muhl.) Bicknell, Bull. Torr. Club, **23**: 509. 1896.
Coll.: Lyon 196, 228, Crooked Creek. July.

Rose blanda Ait. Hort. Kew. **2**: 202. 1789.
Coll.: Lyon 37, 431, Winnebago. June, Aug.

Rosa arkansana Porter, Syn. Fl. Colo. 38. 1874.
Coll.: Wheeler 441, Lyon 343, Jefferson; Lyon 339, Winnebago. Aug.

POMACEÆ.

Malus ioensis (Wood) Britton, in Britt. & Brown, Ill. Fl. **2**: 235. *f. 1980.* 1897.
Coll.: Wheeler 88, 160, Winnebago; 605, Crooked Creek. June, Aug.

Amelanchier canadensis (L.) Medic. Geschichte, 79. 1793.
Coll.: Wheeler 37, 500, Winnebago. June, Aug.

Amelanchier botryapium (L. f.) DC. Prodr. **2**: 632. 1825.
Coll.: Wheeler 253, Winnebago. June.

Amelanchier alnifolia Nutt.; T. & G. Fl. N. A. **1**: 473. As synonym. 1840.
Coll.: Wheeler 203, Winnebago. June.

Cratægus punctata Jacq. Hort. Vind. **1**: 10. *pl. 28.* 1770.
Coll.: Wheeler 141, 651, Winnebago. June, Aug.

Cratægus coccinea L. Sp. Pl. 476. 1753.
Coll.: Lyon 101, Winnebago, June.

Cratægus macracantha Lodd.; Loudon, Arb. Brit. Ed. 2, **2**: 819. 1854.
Coll.: Wheeler 499, Winnebago. Aug.
Not previously reported from Minnesota.

Cratægus tomentosa L. Sp. Pl. 476. 1753.
Coll.: Lyon 3, Wheeler 140, Winnebago. June.

DRUPACEÆ.

Prunus americana Marsh. Arb. Am. 111. 1785.
Coll.: Wheeler 353, Crooked Creek. July.

Prunus nigra Ait. Hort. Kew. 2: 165. 1789.
Coll.: Wheeler 321, 354, Mayville; 501, Winnebago. July, Aug.

Not previously reported from Minnesota. This species has been recognized by horticulturists in several parts of the state but no previous authentic collections are known to have been made. It is common on the lowlands of the North and South forks of Crooked creek. Also collected on the banks of Winnebago creek and in East Burns valley, Winona county.

Prunus virginiana L. Sp. Pl. 473. 1753.
Coll.: Wheeler 345, Crooked Creek. July.

Prunus serotina Ehrh. Beitr. 3: 20. 1788.
Coll.: Wheeler 178, Winnebago. June.

CÆSALPINACEÆ.

Cassia chamæcrista L. Sp. Pl. 379. 1753.
Coll.: Lyon 256, Jefferson. July.

Gleditsia triacanthos L. Sp. Pl. 1056. 1753.
Coll.: Lyon and Wheeler; 413, W. Jefferson. July.

Not previously reported from Minnesota. This tree has been frequently cultivated for ornament throughout the southern part of the state but no native trees have previously been reported. It is frequent on the islands of the Mississippi river in northeastern Iowa and extends north along the river into Houston county, Minnesota, where it probably reaches its northern limit. The tree from which the collection was made is 59 feet high and has a trunk-circumference of 6 feet, 3 feet from the ground.

Gymnocladus dioica Koch, Dendrol. 1: 5. 1869.
Coll.: Lyon 193, 230, Crooked Creek; 271, Jefferson. July. (Plate XXIV., A.)

PAPILIONACEÆ.

Baptisia bracteata Ell. Bot. S. C. & Ga. 1: 469. 1817.
Coll.: Wheeler 94, Lyon 34, Winnebago; Lyon 202, Crooked Creek. June, July.

Baptisia leucantha T. & G. Fl. N. A. 1: 385. 1840.
Coll.: Lyon 194, Crooked Creek. July.

Trifolium hybridum L. Sp. Pl. 766. 1753.
Coll.: Lyon 421, Winnebago. Aug.

Trifolium repens L. Sp. Pl. 767. 1753.
Coll.: Lyon 118, Winnebago. June.

Amorpha fruticosa L. Sp. Pl. 713. 1753.
Coll.: Lyon 473, Jefferson. Aug.

Amorpha canescens PURSH, Fl. Am. Sept. 467. 1814.
Coll.: Wheeler 291, Mayville. July.

Kuhnistera candida (WILLD.) KUNTZE, Rev. Gen. Pl. 192. 1891.
Coll.: Wheeler 397, Jefferson. July.

Kuhnistera purpurea (VENT.) MACM. Met. Minn. 329. 1892.
Coll.: Lyon 262, Jefferson. July.

Astragalus carolinianus L. Sp. Pl. 757. 1753.
Coll.: Lyon 257, 395, Jefferson. July, Aug.

Meibomia grandiflora (WALT.) KUNTZE, Rev. Gen. Pl. 196. 1891.
Coll.: Lyon 198, 246, Crooked Creek. July.

Meibomia dillenii (DARL.) KUNTZE, Rev. Gen. Pl. 195. 1891.
Coll.: Wheeler 482, Jefferson. Aug.
No previously collected Minnesota specimens in the Herbarium of the University.

Meibomia illinoensis (A. GRAY) KUNTZE, Rev. Gen. Pl. 198. 1891.
Coll.: Wheeler 390, 446, Jefferson; 609, Brownsville. July, Aug.
Not previously reported from Minnesota. Frequent and in some places common in dry fields and hillsides.

Meibomia canadensis (L.) KUNTZE, Rev. Gen. Pl. 195. 1891.
Coll.: Wheeler 331, Crooked Creek. July.

Lespedeza capitata MICHX. Fl. Bor. Am. 2: 71. 1803.
Coll.: Wheeler 525, Jefferson. Aug.

Lathyrus venosus MUHL.; Willd. Sp. Pl. 3: 1092. 1803.
Coll.: Lyon 48, Winnebago. June.

Lathyrus ochroleucus HOOK. Fl. Bor. Am. 1: 159. 1833.
Coll.: Lyon 87, Winnebago. June.

Falcata comosa (L.) KUNTZE, Rev. Gen. Pl. 182. 1891.
Coll.: Wheeler 507, Lyon 332, Winnebago; Lyon 469, Jefferson. Aug.

Falcata pitcheri (T. & G.) KUNTZE, Rev. Gen. Pl. 182. 1891.
Coll.: Wheeler 573, Jefferson. Aug.

Not previously reported from Minnesota. Several specimens of this species, previously reported as *F. comosa*, have been collected in southern Minnesota. Probably common throughout the southern part of the state.

Apios apios (L.) MACM. Bull. Torr. Club, **19**: 15. 1892.
Coll.: Wheeler, 337, Crooked Creek; Wheeler 399, Lyon 388, Jefferson. July, Aug.

Strophostyles helvola (L.) BRITTON in Britt. & Brown, Ill. Fl. 2: 338. *f. 2235*. 1897.
Coll.: Lyon 387, Jefferson. Aug.

GERANIACEÆ.

Geranium maculatum L. Sp. Pl. 681. 1753.
Coll.: Lyon 4, Winnebago. June.

OXALIDACEÆ.

Oxalis violacea L. Sp. Pl. 434. 1753.
Coll.: Lyon 50, Winnebago. June.

Oxalis stricta L. Sp. Pl. 435. 1753.
Coll.: Lyon 81, Winnebago. June.

LINACEÆ.

Linum sulcatum RIDDEL, Suppl. Cat. Ohio Pl. 10. 1836.
Coll.: Wheeler 290, Mayville; 431, Jefferson. July.

RUTACEÆ.

Xanthoxylum americanum MILL. Gard. Dict. Ed. 8, No. 2. 1768.
Coll.: Wheeler 132, 413, Winnebago. June, Aug.

POLYGALACEÆ.

Polygala verticillata L. Sp. Pl. 706. 1753.
Coll.: Wheeler 342, Crooked Creek; 428, Jefferson. July.

Polygala viridescens L. Sp. Pl. 705. 1753.
Coll.: Lyon 483, Jefferson. Aug.

Polygala senega L. Sp. Pl. 704. 1753.
Coll.: Lyon 21, Winnebago. June.

EUPHORBIACEÆ.

Acalypha virginica L. Sp. Pl. 1003. 1753.
Coll.: Lyon 349, 397, 463, Jefferson. Aug.

Euphorbia glyptosperma ENGELM. Bot. Mex. Bound. Surv. 187. 1859.
Coll.: Wheeler 434, Jefferson. July.

Euphorbia maculata L. Sp. Pl. 455. 1753.
Coll.: Wheeler 430, Jefferson. July.

Euphorbia nutans LAG. Gen. & St. 17. 1816.
Coll.: Wheeler 336, Crooked Creek. July.

Euphorbia corollata L. Sp. Pl. 459. 1753.
Coll.: Lyon 189, Wheeler 375, Crooked Creek. July.

Euphorbia heterophylla L. Sp. Pl. 453. 1753.
Coll.: Wheeler 466, Jefferson. Aug.

Euphorbia cyparissias L. Sp. Pl. 461. 1753.
Coll.: Lyon 437, Jefferson. Aug.

ANACARDIACEÆ.

Rhus hirta (L.) SUDW. Bull. Torr. Club, **19**: 82. 1892.
Coll.: Lyon 319, Jefferson. Aug.

Rhus glabra L. Sp. Pl. 265. 1753.
Coll.: Lyon 272, Jefferson. July.

Rhus radicans L. Sp. Pl. 266. 1753.
Coll.: Lyon 327, 350, Jefferson. Aug.

CELASTRACEÆ.

Euonymus atropurpureus JACQ. Hort. Vind. **2**: 5. *pl. 120.* 1772.
Coll.: Lyon 140, Winnebago; 263, Jefferson. June, July.

Celastrus scandens L. Sp. Pl. 196. 1753.
Coll.: Wheeler 104, Winnebago; Lyon 380, Jefferson. June, Aug.

STAPHYLEACEÆ.

Staphylea trifolia L. Sp. Pl. 270. 1753.
Coll.: Wheeler 202, Winnebago. June.

ACERACEÆ.

Acer saccharinum L. Sp. Pl. 1055. 1753.
Coll.: Lyon 149, Winnebago; 274, Jefferson. June, July.

Acer nigrum Michx. f. Hist. Arb. Am. 2: 238. *pl. 16.* 1810.
Coll.: Wheeler 149, Winnebago. June.

Acer spicatum Lam. Encycl. 2: 381. 1786.
Coll.: Wheeler 163, 198, Winnebago; 319, Mayville; 625, Brownsville. June, Aug.
Frequent on moist shaded cliffs throughout.

Acer negundo L. Sp. Pl. 1056. 1753.
Coll.: Lyon 119, Winnebago. June.

BALSAMINACEÆ.

Impatiens aurea Muhl. Cat. 26. 1813.
Coll.: Wheeler 328, Mayville. July.

RHAMNACEÆ.

Ceanothus americanus L. Sp. Pl. 195. 1753.
Coll.: Lyon 66, Winnebago; Wheeler 356, Crooked Creek. June, July.

Ceanothus ovatus Desf. Hist. Arb. 2: 381. 1809.
Coll.: Wheeler 92, Lyon 66½, Winnebago. June.

VITACEÆ.

Vitis vulpina L. Sp. Pl. 203. 1753.
Coll.: Wheeler 139, Winnebago; 344, Crooked Creek. June, July.

Parthenocissus quinquefolia (L.) Planch. in DC. Mon. Phan. 5: Part 2, 448. 1887.
Coll.: Wheeler 235, Winnebago; Lyon 379, Jefferson. June, Aug.

TILIACEÆ.

Tilia americana L. Sp. Pl. 514. 1753.
Coll.: Lyon 211, Mayville. July.

MALVACEÆ.

Malva rotundifolia L. Sp. Pl. 688. 1753.
Coll.: Lyon 491, Jefferson. Aug.

Napæa dioica L. Sp. Pl. 686. 1753.
Coll.: Lyon 266, Jefferson. July.
Previously collected at Vasa and Lanesboro. Rare on lowland near Winnebago creek.

Abutilon abutilon (L.) RUSBY, Mem. Torr. Club, **5**: 222. 1894.
Coll.: Lyon 283, Jefferson. July.

HYPERICACEÆ.

Hypericum ascyron L. Sp. Pl. 783. 1753.
Coll.: Lyon 235, Crooked Creek; 436, Winnebago. June, Aug.

Hypericum maculatum WALT. Fl. Car. 189. 1788.
Coll.: Wheeler 442, 483, Jefferson; 615, Brownsville; Lyon 452, Jefferson. Aug.

Hypericum majus (A. GRAY) BRITTON, Mem. Torr. Club, **5**: 225. 1894.
Coll.: Wheeler 427, Jefferson; 601, Crooked Creek. July, Aug.

CISTACEÆ.

Helianthemum majus (L.) B.S.P. Prel. Cat. N. Y. 6. 1888.
Coll.: Lyon 167, Crooked Creek; Wheeler 477, Jefferson; 633, Brownsville. Aug.

Helianthemum canadense (L.) MICHX. Fl. Bor. Am. **1**: 308. 1803.
Coll.: Wheeler 631, Brownsville. Aug.

Lechea stricta LEGGETT; BRITTON, Bull. Torr. Club, **21**: 251. 1894.
Coll.: Wheeler 359, Crooked Creek; Lyon 331, Winnebago. July, Aug.

VIOLACEÆ.

Viola pedatifida DON, Gard. Dict. **1**: 320. 1831.
Coll.: Wheeler 429, Jefferson. July.

Viola obliqua HILL, Hort. Kew. 316. *pl. 12.* 1769.
Coll.: Wheeler 114, Winnebago. June.

Viola pedata L. Sp. Pl. 933. 1753.
Coll.: Wheeler 216, Jefferson. June.

Viola pubescens AIT. Hort. Kew. **3**: 290. 1789.
Coll.: Wheeler 205, Winnebago. June.

THYMELEACEÆ.

Dirca palustris L. Sp. Pl. 358. 1753.
Coll.: Wheeler 520, Winnebago. Aug.
Rare in moist thickets near Winnebago creek.

LYTHRACEÆ.

Lythrum alatum PURSH, Fl. Am. Sept. 334. 1814.
Coll.: Lyon 281, Wheeler 416, Jefferson. July.

ONAGRACEÆ.

Epilobium coloratum MUHL.; Willd. Enum. **1**: 411. 1809.
Coll.: Wheeler 479, Jefferson; 608, Brownsville. Aug.

Epilobium adenocaulon HAUSSK. Oest. Bot. Zeit. **29**: 119. 1879.
Coll.: Wheeler 323, Mayville; 595, Crooked Creek; Lyon 457, Jefferson. July, Aug.

Onagra biennis (L.) SCOP. Fl. Carn. Ed. 2, **1**: 269. 1772.
Coll.: Lyon 166½, Winnebago; 286, Jefferson. June, July.

Œnothera rhombipetala NUTT.; T. & G. Fl. N. A. **1**: 493. 1840.
Coll.: Lyon 323, Jefferson. Aug.

Gaura biennis L. Sp. Pl. 347. 1753.
Coll.: Wheeler 574, Jefferson. Aug.
No previous authentic collection from Minnesota. There are no Minnesota specimens in the Herbarium of the University. Miss Manning's collection of 1883 from Pepin, Wis., is probably the one upon which is based the report of this species by Upham and others.

Circæa lutetiana L. Sp. Pl. 9. 1753.
Coll.: Wheeler 270, Crooked Creek. June.

Circæa alpina L. Sp. Pl. 9. 1753.
Coll.: Lyon 152, Winnebago. June.

ARALIACEÆ.

Aralia racemosa L. Sp. Pl. 273. 1753.
Coll.: Lyon 345, Jefferson. Aug.

Aralia nudicaulis L. Sp. Pl. 274. 1753.
Coll.: Lyon 15, Winnebago. June.

Panax quinquefolium L. Sp. Pl. 1058. 1753.
Coll.: Lyon 210, Mayville; Wheeler 469, Jefferson. July, Aug.

UMBELLIFERÆ.

Angelica atropurpurea L. Sp. Pl. 251. 1753.
Coll.: Wheeler 311, Crooked Creek. July.

Heracleum lanatum MICHX. Fl. Bor. Am. 1: 166. 1803.
Coll.: Lyon 93, Winnebago. June.

Sanicula marylandica L. Sp. Pl. 235. 1753.
Coll.: Wheeler 175, Winnebago. June.

Sanicula gregaria BICKNELL, Bull. Torr. Club, **22**: 354. 1895.
Coll.: Wheeler 177, Winnebago. June.

The only precious collection from Minnesota is that of Sheldon, Milaca, 1892.

Sanicula canadensis L. Sp. Pl. 235. 1753.
Coll.: Lyon 260, Jefferson. July.

Sanicula trifoliata BICKNELL, Bull. Torr. Club, **22**: 359. 1895.
Coll.: Lyon 214, Mayville. July.

Not previously reported from Minnesota.

Pimpinella integerrima (L.) A. GRAY, Proc. Am. Acad. **7**: 345. 1868.
Coll.: Wheeler 179, Winnebago. June.

Washingtonia claytoni (MICHX.) BRITTON in Brit. & Brown, Ill. Fl. **2**: 530. *f. 2680.* 1897.
Coll.: Lyon 7, Winnebago. June.

Sium cicutæfolium GMEL. Syst. **2**: 482. 1791.
Coll.: Wheeler 545, Lyon 449, Jefferson. Aug.

Zizia aurea (L.) KOCH, Nov. Act. Caes. Leop. **12**: 129. 1825.
Coll.: Wheeler 174, Winnebago; Lyon 261, Jefferson. June, July.

Zizia cordata DC. Prodr. **4**: 100. 1830.
Coll.: Lyon 292, 352, Jefferson. July.

Cicuta maculata L. Sp. Pl. 256. 1753.
Coll.: Wheeler 338, Crooked Creek. July.

Cicuta bulbifera L. Sp. Pl. 255. 1753.
Coll.: Wheeler 607, Brownsville. Aug.

Deringa canadensis (L.) Kuntze, Rev. Gen. Pl. 266. 1891.
Coll.: Wheeler 193, Winnebago. June.

Berula erecta (Huds.) Coville, Contr. Nat. Herb. **4**: 115. 1893.
Coll.: Wheeler 588, Crooked Creek. Aug.
In cold springs at the head of Clear creek.

Hydrocotyle americana L. Sp. Pl. 234. 1753.
Coll.: Wheeler 314, Mayville. July.
The only previously reported locality of collection is St. Croix Falls. Rare in moist woods near Crooked creek.

CORNACEÆ.

Cornus circinata L'Her. Cornus, 7. *pl. 3.* 1788.
Coll.: Wheeler 81, Winnebago. June.

Cornus amonum Mill. Gard. Dict. Ed. 8, No. 5. 1768.
Coll.: Lyon 351, Jefferson. Aug.

Cornus stolonifera Michx. Fl. Bor. Am. **1**: 92. 1803.
Coll.: Wheeler 69, 173, Winnebago. June.

Cornus candidissima Marsh, Arb. Am. 35. 1785.
Coll.: Wheeler 172, Winnebago. June.

PYROLACEÆ.

Pyrola elliptica Nutt. Gen. **1**: 273. 1818.
Coll.: Wheeler 191, Winnebago; 276, Crooked Creek. June, July.

ERICACEÆ.

Arctostaphylos uva-ursi (L.) Spreng. Syst. **2**: 287. 1825.
Coll.: Lyon 116, Jefferson. June.
On a sandy point of a bluff in section 19 of Jefferson.

PRIMULACEÆ.

Lysimachia terrestris (L.) B.S.P. Prel. Cat. N. Y. 34. 1888.
Coll.: Lyon 249, Crooked Creek. July.

Steironema ciliatum (L.) Raf. Ann. Gen. Phys. **7**: 192. 1820.
Coll.: Lyon 251, Crooked Creek. July.

Dodecatheon meadia L. Sp. Pl. 144. 1753.
Coll.: Wheeler 340, Crooked Creek. July.

Previously collected only in Winona and Wabasha counties. Rare in moist woods.

OLEACEÆ.

Fraxinus lanceolata BORCK. Handb. Forst. Bot. 1: 826. 1800.
Coll.: Lyon 300, Jefferson. Aug.

Fraxinus nigra MARSH. Arb. Am. 51. 1785.
Coll.: Lyon 173, Crooked Creek. June. (Plate XXIII., B.)

GENTIANACEÆ.

Gentiana crinita FROEL. Gen. 112. 1796.
Coll.: Lyon 454, 488, Jefferson. Aug.

Gentiana quinquefolia L. Sp. Pl. 230. 1753.
Coll.: Lyon 455, 487, Jefferson. Aug.

Gentiana flavida A. GRAY, Journ. Sci. (II.) 1: 180. 1846.
Coll.: Wheeler 516, Winnebago; 596, Crooked Creek. Aug.

APOCYNACEÆ.

Apocynum androsæmifolium L. Sp. Pl. 213. 1753.
Coll.: Lyon 188, Crooked Creek. July.

Apocynum cannabinum L. Sp. Pl. 213. 1753.
Coll.: Lyon 471, Jefferson. Aug.

Apocynum cannabinum glaberrimum DC. Prodr. 8: 439. 1844.
Coll.: Lyon 357, Jefferson. Aug.

ASCLEPIADACEÆ.

Asclepias tuberosa L. Sp. Pl. 217. 1753.
Coll.: Wheeler 287, 369, Crooked Creek; Lyon 356, Jefferson. July, Aug.

Asclepias incarnata L. Sp. Pl. 215. 1753.
Coll.: Lyon 177, Winnebago; 365, Jefferson. June, Aug.

Asclepias obtusifolia MICHX. Fl. Bor. Am. 1: 115. 1803.
Coll.: Wheeler 569, Jefferson. Aug.

Previously reported only by Lapham. Infrequent on dry hillsides.

Asclepias exaltata (L.) MUHL. Cat. 28. 1813.
Coll.: Lyon 178, Winnebago. July.

Asclepias syriaca L. Sp. Pl. 214. 1753.
Coll.: Lyon 176, Winnebago. July.

Asclepias verticillata L. Sp. Pl. 217. 1753.
Coll.: Wheeler 286, Crooked Creek; 378, Jefferson. July.

Acerates viridiflora (RAF.) EATON, Man. Ed. 5, 90. 1829.
Coll.: Lyon 179, Winnebago; 309½, Jefferson. July, Aug.

CONVOLVULACEÆ.

Convolvulus sepium L. Sp. Pl. 153. 1753.
Coll.: Wheeler 306, Crooked Creek. July.

Convolvulus spithamæus L. Sp. Pl. 158. 1753.
Coll.: Wheeler 207, Winnebago; 358, 371, Crooked Creek; 385, Jefferson. June, July.

CUSCUTACEÆ.

Cuscuta indecora CHOISY, Mem. Soc. Gen. 9: 278. *pl. 3. f. 5.* 1841.
Coll.: Wheeler 436, 557, 647, Jefferson. July, Aug.

Cuscuta coryli ENGELM. Am. Journ. Sci. **43**: 337. *f. 7–11.* 1842.
Coll.: Wheeler 503, Winnebago. Aug.

Cuscuta gronovii WILLD.: R. & S. Syst. **6**: 205. 1820.
Coll.: Wheeler 308, 592, Crooked Creek; 438, 440, Jefferson. July, Aug.

Cuscuta paradoxa RAF. Ann. Nat. 13. 1820.
Coll.: Wheeler 437, 648, Jefferson. July, Aug.

POLEMONIACEÆ.

Phlox pilosa L. Sp. Pl. 152. 1753.
Coll.: Herb. Wheeler 14, Winnebago. June.

Phlox divaricata L. Sp. Pl. 152. 1753.
Coll.: Lyon 5, Winnebago. June.

Polemonium reptans L. Syst. Ed. 10, No. 1. 1759.
Coll.: Wheeler 33, Winnebago. June.

HYDROPHYLLACEÆ.

Hydrophyllum virginicum L. Sp. Pl. 146. 1753.
Coll.: Lyon 11, Winnebago. June.

Hydrophyllum appendiculatum MICHX. Fl. Bor. Am. **1**: 134. 1803.
Coll.: Wheeler 324, Mayville. July.

Macrocalyx nyctelea (L.) KUNTZE, Rev. Gen. Pl. 434. 1891.
Coll.: Lyon 19, Winnebago. June.

BORAGINACEÆ.

Lappula lappula (L.) KARST. Deutsch. Fl. 979. 1880–83.
Coll.: Lyon 186, Crooked Creek. July.

Lappula virginianum (L.) GREENE, Pittonia, 2: 182. 1891.
Coll.: Lyon 237, Mayville. July.

Lithospermum gmelini (MICHX.) A. S. HITCHCOCK, Spring Fl. Manh. 30. 1894.
Coll.: Lyon 281½, Jefferson. July.

Lithospermum canescens (MICHX.) LEHM. Asperif. 305. 1818.
Coll.: Lyon 27, Winnebago. June.

Lithospermum angustifolium MICHX. Fl. Bor. Am. 1: 130. 1803.
Coll.: Wheeler 450, Jefferson. Aug.

Onosmodium caroliniana (LAM.) DC. Prodr. 10: 70. 1846.
Coll.: Wheeler 352, Crooked Creek. July.

Lycopsis arvensis L. Sp. Pl. 139. 1753.
Coll.: Lyon 110, Winnebago. June.
Not previously reported from Minnesota.

VERBENACEÆ.

Verbena urticifolia L. Sp. Pl. 20. 1753.
Coll.: Wheeler 406, 548, Jefferson. July, Aug.

Verbena hastata L. Sp. Pl. 20. 1753.
Coll.: Wheeler 403, Jefferson. July.

Verbena stricta VENT. Desc. Pl. Jard. Cels. *pl. 53*. 1800.
Coll.: Wheeler 401, Jefferson. July.

Verbena bracteosa MICHX. Fl. Bor. Am. 2: 13. 1803.
Coll.: Wheeler 635, Brownsville. Aug.

Lippia lanceolata MICHX. Fl. Bor. Am. 2: 15. 1803.
Coll.: Lyon 279, Jefferson; Wheeler 622, Brownsville. July, Aug.
Common on the very low lands of the Mississippi river.

LABIATÆ.

Teucrium canadense L. Sp. Pl. 564. 1753.
Coll.: Wheeler 414, Jefferson. July.

Scutellaria lateriflora L. Sp. Pl. 598. 1753.
Coll.: Wheeler 455, Jefferson; 517, Winnebago. Aug.

Scutellaria cordifolia MUHL. Cat. 56. 1813.
Coll.: Wheeler 468, Jefferson. Aug.

Scutellaria parvula MICHX. Fl. Bor. Am. 2: 11. 1803.
Coll.: Lyon 39, Winnebago. June.

Agastache scrophulariæfolia (WILLD.) KUNTZE, Rev. Gen. Pl. 511. 1891.
Coll.: Wheeler, 465, Jefferson; Lyon 315, Winnebago. Aug.

Nepeta cataria L. Sp. Pl. 570. 1753.
Coll.: Lyon 288, 492, Jefferson. July.

Glecoma hederacea L. Sp. Pl. 578. 1753.
Coll.: Lyon 229, Crooked Creek. July.

Prunella vulgaris L. Sp. Pl. 600. 1753.
Coll.: Wheeler 407, Jefferson. July.

Physostegia virginiana (L.) BENTH. Lab. Gen. and Sp. 504. 1834.
Coll.: Lyon 295, Jefferson. July.

Leonurus cardiaca L. Sp. Pl. 584. 1753.
Coll.: Wheeler 256, Lyon 418, Winnebago; Wheeler 295, Mayville. June, July, Aug.

Stachys palustris L. Sp. Pl. 580. 1753.
Coll.: Wheeler 300, Crooked Creek. July.

Monarda fistulosa L. Sp. Pl. 22. 1753.
Coll.: Lyon 185, Crooked Creek. July.

Blephila hirsuta (PURSH) TORR. Fl. U. S. 27. 1824.
Coll.: Lyon 225, Mayville; Wheeler 498, Winnebago. July, Aug.

Hedeoma pulegioides (L.) PERS. Syn. 2: 131. 1807.
Coll.: Wheeler 610, Brownsville. Aug.

Previously reported from the Mississippi river by Garrison and Miss Manning, but there are no Minnesota specimens in the Herbarium of the University.

Hedeoma hispida PURSH, Fl. Am. Sept. 414. 1814.
Coll.: Lyon 51, Winnebago. June.

Clinopodium vulgare L. Sp. Pl. 587. 1753.
Coll.: Lyon 411, Winnebago. Aug.

Kœllia virginiana (L.) MacM. Met. Minn. 452. 1892.
Coll.: Wheeler 363, Crooked Creek; 405, Jefferson. July.

Lycopus virginicus L. Sp. Pl. 21. 1753.
Coll.: Wheeler 537, Jefferson. Aug.

Lycopus rubellus Moench, Meth. Suppl. 146. 1802.
Coll.: Lyon 314, 417, Winnebago. Aug.

Lycopus americanus Muhl.; Bart. Fl. Phil. Prodr. 15. 1815.
Coll.: Lyon 335, 348, Jefferson. Aug.

Lycopus lucidus Turcz.; Benth. in DC. Prodr. **12**: 178. 1848.
Coll.: Lyon 459, Jefferson. Aug.

Mentha canadensis L. Sp. Pl. 577. 1753.
Coll.: Lyon 199, Crooked Creek. July.

SOLANACEÆ.

Physalis philadelphica Lam. Encycl. **2**: 101. 1786.
Coll.: Lyon 359, Jefferson. Aug.

Mr. Rydberg says: "This is a very peculiar form that I have never seen before. It may be a new species but in order to make a good description fruit is required. At present it should be referred to *P. philadelphica* with which it agrees except in the very large and broad leaves. In that respect it resembles *P. macrophysa* Rydb. but the latter is a perennial not an annual as this plant."

Physalis virginiana Mill. Gard. Dict. Ed. 8, No. 4. 1768.
Coll.: Lyon 63, Winnebago. June.

Physalis heterophylla Nees, Linnæa, **6**: 463. 1831.
Coll.: Lyon 150, Winnebago. June.

Solanum nigrum L. Sp. Pl. 186. 1753.
Coll.: Lyon 192, Crooked Creek. July.

Datura tatula L. Sp. Pl. Ed. 2, 256. 1762.
Coll.: Wheeler 379, Jefferson. July.

SCROPHULARIACEÆ.

Verbascum thapsus L. Sp. Pl. 177. 1753.
Coll.: Wheeler 474, Jefferson. Aug.

Scrophularia marylandica L. Sp. Pl. 619. 1753.
Coll.: Lyon 190, Winnebago; 353, Jefferson. June, Aug.

Chelone glabra L. Sp. Pl. 611. 1753.
Coll.: Wheeler 586, Crooked Creek. Aug.

Mimulus ringens L. Sp. Pl. 634. 1753.
Coll.: Wheeler 383, 546, Jefferson. July, Aug.

Mimulus jamesii T. & G.; BENTH. in DC. Prodr. **10**: 371. 1846.
Coll.: Lyon 68, Winnebago; Wheeler 589, Crooked Creek. June, Aug.

Ilysanthes gratioloides (L.) BENTH. in DC. Prodr. **10**: 419. 1846.
Coll.: Lyon 361, 382, Jefferson; Wheeler 578½, Crooked Creek. Aug.

Veronica americana SCHWEIN.; BENTH. in DC. Prodr. **10**: 468. 1846.
Coll.: Wheeler 147, Winnebago. June.

Veronica peregrina L. Sp. Pl. 14. 1753.
Coll.: Lyon 83, Winnebago; Wheeler 415, Jefferson. June, July.

Leptandra virginica (L.) NUTT. Gen. **1**: 7. 1818.
Coll.: Lyon 234, 250, Crooked Creek. July.

Dasystoma grandiflora (BENTH.) WOOD. Bot. & Flor. 231. 1873.
Coll.: Wheeler 512, Winnebago. Aug.

This is the first authentic specimen of this seen from Minnesota.

Gerardia aspera DOUGL.: BENTH. in DC. Prodr. **10**: 517. 1846.
Coll.: Lyon 407, Jefferson. Aug.

Gerardia tenuifolia VAHL, Symb. Bot. **3**: 79. 1794.
Coll.: Lyon 406, 456, Wheeler 575, Jefferson; Wheeler 602, Crooked Creek. Aug.

Castilleja coccinea (L.) SPRENG. Syst. **2**: 775. 1825.
Coll.: Wheeler 85, Winnebago. June.

Castilleja sessiliflora PURSH, Fl. Am. Sept. 738. 1814.
Coll.: Lyon 69, Winnebago. June.

Pedicularis lanceolata MICHX. Fl. Bor. Am. **2**: 18. 1803.
Coll.: Wheeler 515, Winnebago; 600, Crooked Creek. Aug.

Pedicularis canadensis L. Mant. 86. 1767.
Coll.: Lyon 35, Winnebago. June.

LENTIBULARIACEÆ.

Utricularia vulgaris L. Sp. Pl. 18. 1753.
Coll.; Lyon 267, Wheeler 459, Jefferson. July, Aug.

OROBANCHACEÆ.

Thalesia uniflora (L.) BRITTON, Mem. Torr. Club, 5: 298. 1894.
Coll.: Lyon 70, Winnebago. June.

PHRYMACEÆ.

Phryma leptostachya L. Sp. Pl. 601. 1753.
Coll.: Wheeler 298, Crooked Creek. July.

PLANTAGINACEÆ.

Plantago major L. Sp. Pl. 112. 1753.
Coll.: Lyon 124, Winnebago. June.

RUBIACEÆ.

Cephalanthus occidentalis L. Sp. Pl. 95. 1753.
Coll.: Wheeler 365, Crooked Creek; 435, Jefferson; 624, Brownsville. July, Aug.

Common on the lowlands of the Mississippi river.

Galium aparine L. Sp. Pl. 108. 1753.
Coll.: Wheeler 9, Winnebago. June.

Galium boreale L. Sp. Pl. 108. 1753.
Coll.: Lyon 53, Winnebago; 199½, Crooked Creek. June, July.

Galium triflorum MICHX. Fl. Bor. Am. 1: 80. 1803.
Coll.: Wheeler 41, Winnebago. June.

Galium trifidum L. Sp. Pl. 105. 1753.
Coll.: Wheeler 42, Winnebago. June.

Galium asprellum MICHX. Fl. Bor. Am. 1: 78. 1803.
Coll.: Wheeler 593, Crooked Creek. Aug.

CAPRIFOLIACEÆ.

Sambucus canadensis L. Sp. Pl. 269. 1753.
Coll.: Wheeler 412, 649, Jefferson. July, Aug.

Sambucus pubens MICHX. Fl. Bor. Am. 1: 181. 1803.
Coll.: Wheeler 133, Winnebago. June.

Viburnum opulus L. Sp. Pl. 268. 1753.
Coll.: Lyon 129, Winnebago; Wheeler 591, Crooked Creek. June, Aug.

Viburnum dentatum L. Sp. Pl. 268. 1753.
Coll.: Wheeler 201, Winnebago. June.

Viburnum lentago L. Sp. Pl. 268. 1753.
Coll.: Wheeler 39, Winnebago. June.

Triosteum perfoliatum L. Sp. Pl. 176. 1753.
Coll.: Wheeler 2, Winnebago. June.

Lonicera dioica L. Syst. Ed. 12, 165. 1767.
Coll.: Wheeler 190, Winnebago. June.

Lonicera sullivantii A. GRAY, Proc. Amer. Acad. **19**: 76. 1883.
Coll.: Wheeler 122, Winnebago. June.

Diervilla diervilla (L.) MACM., Bull. Torr. Club, **19**: 15. 1892.
Coll.: Lyon 46, Winnebago. June.

ADOXACEÆ.

Adoxa moschatellina L. Sp. Pl. 367. 1753.
Coll.: Wheeler 196, Winnebago. June.
Frequent in moist woods.

VALERIANACEÆ.

Valeriana edulis NUTT. in T. & G. Fl. N. A. **2**: 48. 1841.
Coll.: Wheeler 159, Winnebago. June.

CAMPANULACEÆ.

Campanula rotundifolia L. Sp. Pl. 163. 1753.
Coll.: Lyon 36, Winnebago. June.

Campanula aparinoides PURSH, Fl. Am. Sept. 159. 1814.
Coll.: Lyon 194½, Crooked Creek. July.

Campanula americana L. Sp. Pl. 164. 1753.
Coll.: Wheeler 339, Crooked Creek. July.

Legouzia perfoliata (L.) BRITTON, Mem. Torr. Club, **5**: 309. 1894.
Coll.: Lyon 148, Winnebago. June.

Lobelia cardinalis L. Sp. Pl. 930. 1753.
Coll.: Wheeler 464, Jefferson; 578, Crooked Creek. Aug.

Lobelia syphilitica L. Sp. Pl. 931. 1753.
Coll.: Lyon 310, 340, Jefferson. Aug.

Lobelia spicata LAM. Encycl. **3**: 587. 1789.
Coll.: Lyon 115, Jefferson. June.

Lobelia inflata L. Sp. Pl. 931. 1753.
Coll.: Wheeler 480, 554, Jefferson; 612, Brownsville. Aug.

CICHORIACEÆ.

Cichorium intybus L. Sp. Pl. 813. 1753.
Coll.: Wheeler 594, Lyon 468, Crooked Creek. Aug.

Adopogon virginicum (L.) KUNTZE, Rev. Gen. Pl. 304. 1891.
Coll.: Lyon 20, 337, Wheeler 506, Winnebago. June, Aug.

Taraxacum taraxacum (L.) KARST. Deutsch. Fl. 1138. 1880–83.
Coll.: Lyon 121, Winnebago. June.

Sonchus asper (L.) ALL. Fl. Ped. **1**: 222. 1785.
Coll.: Lyon 264, Jefferson. July.

Lactuca scariola L. Sp. Pl. Ed. 2, 1119. 1763.
Coll.: Lyon 374, Jefferson. Aug.

Lactuca ludoviciana (NUTT.) DC. Prodr. **7**: 141. 1838.
Coll.: Lyon 285, 445, 447, Jefferson. July.
Previously reported only by Sheldon from Sleepy Eye.

Lactuca sagittifolia ELL. Bot. S. C. & Ga. **2**: 253. 1821–24.
Coll.: Lyon 363, Jefferson. Aug.
Previously reported only by Sheldon from Lake Benton.

Lactuca floridana (L.) GAERTN. Fruct. & Sem. **2**: 362. 1791.
Coll.: Lyon 334, 410, 423, Winnebago. Aug.

Hieracium umbellatum L. Sp. Pl. 804. 1753.
Coll.: Wheeler 627, Brownsville. Aug.
No authentic specimens previously reported from Minnesota.

Hieracium canadense MICHX. Fl. Bor. Am. **2**: 86. 1803.
Coll.: Wheeler 443, Jefferson; Lyon 311, 341, Wheeler 510, Winnebago. Aug.

Hieracium scabrum MICHX. Fl. Bor. Am. **2**: 86. 1803.
Coll.: Wheeler 485, Lyon 336, 405, 462, Jefferson; Wheeler 513, Winnebago; Wheeler 636, Brownsville.

Nabalus albus (L.) HOOK. Fl. Bor. Am. **1**: 294. 1833.
Coll.: Wheeler 521, Winnebago. Aug.

AMBROSIACEÆ.

Ambrosia trifida L. Sp. Pl. 987. 1753.
Coll.: Wheeler 417, Jefferson. July.

Ambrosia artemisiæfolia L. Sp. Pl. 987. 1753.
Coll.: Lyon 495, Jefferson. Aug.

Xanthium canadense MILL. Gard. Dict. Ed. 8, No. 2. 1768.
Coll.: Lyon 424, Winnebago. Aug.

COMPOSITÆ.

Vernonia fasciculata Michx. Fl. Bor. Am. 2: 94. 1803.
Coll.: Wheeler, 408, Jefferson. July.

Eupatorium purpureum L. Sp. Pl. 838. 1753.
Coll.: Lyon 347, Wheeler 563, Jefferson; Wheeler 519, Winnebago. Aug.

Eupatorium altissimum L. Sp. Pl. 837. 1753.
Coll.: Wheeler 533, 568, Jefferson; Lyon 412, Winnebago. Aug.

Eupatorium perfoliatum L. Sp. Pl. 838. 1753.
Coll.: Wheeler 493, Jefferson. Aug.

Eupatorium ageratoides L. f. Suppl. 355. 1781.
Coll.: Lyon 293, Jefferson. July.

Kuhnia eupatorioides L. Sp. Pl. Ed. 2, 1662. 1763.
Coll.: Wheeler 532, 555, 571, Lyon 370, 381, 489, Jefferson. Aug.

Lacinaria cylindracea (Michx.) Kuntze, Rev. Gen. Pl. 349. 1891.
Coll.: Lyon 181, Crooked Creek; 290, Jefferson. July.

Lacinaria pycnostachya (Michx.) Kuntze, Rev. Gen. Pl. 349 1891.
Coll.: Lyon 265, Jefferson. July.

Lacinaria scariosa (L.) Hill, Veg. Syst. 4: 49. 1762.
Coll.: Lyon 313, Winnebago. Aug.

Solidago flexicaulis L. Sp. Pl. 879. 1753.
Coll.: Lyon 371½, 484, Jefferson; Wheeler 590, Crooked Creek. Aug.

Solidago hispida Muhl.; Willd. Sp. Pl. 3: 2063. 1804.
Coll.: Lyon 294, Jefferson. July.

Solidago erecta Pursh, Fl. Am. Sept. 542. 1814.
Coll.: Lyon 371, Jefferson. Aug.
Reported from Stearns County but no Minnesota specimens previously seen.

Solidago speciosa Nutt. Gen. 2: 160. 1818.
Coll.: Lyon 467, Jefferson. Aug.

Solidago ulmifolia Muhl.; Willd. Sp. Pl. 3: 2060. 1804.
Coll.: Lyon 433, Winnebago. Aug.

Solidago serotina Ait. Hort. Kew. 3: 211. 1789.
Coll.: Lyon 360, Jefferson. Aug.

Solidago missouriensis Nutt. Journn. Acad. Phila. 7: 32. 1834.
Coll.: Lyon 289, 373, Jefferson. July.

Solidago canadensis L. Sp. Pl. 878. 1753.
Coll.: Lyon 330, Winnebago. Aug.

Solidago nemoralis Ait. Hort. Kew. 3: 213. 1789.
Coll.: Wheeler 611, Brownsville. Aug.

Solidago rigida L. Sp. Pl. 880. 1753.
Coll.: Lyon 372, 403, Jefferson. Aug.

Euthamia graminifolia (L.) Nutt. Gen. 2: 162. 1818.
Coll.: Wheeler 565, Jefferson. Aug.

Boltonia asteroides (L.) L'Her. Sert. Angl. 27. 1788.
Coll.: Lyon 385, Wheeler 561, Jefferson. Aug.

Aster drummondii Lindl. in Hook. Comp. Bot. Mag. 1: 97. 1835.
Coll.: Wheeler 551, Jefferson; Lyon 426, Winnebago. Aug.

Aster sagittifolius Willd. Sp. Pl. 3: 2035. 1804.
Coll.: Lyon 402, 451, Jefferson; Wheeler 583, 599, Crooked Creek. Aug.

Aster patens Ait. Hort. Kew. 3: 201. 1789.
Coll.: Wheeler 584, Crooked Creek. Aug.

Aster novæ-angliæ L. Sp. Pl. 875. 1753.
Coll.: Lyon 425, Winnebago; 482, Jefferson. Aug.

Aster puniceus L. Sp. Pl. 875. 1753.
Coll.: Wheeler 585, Crooked Creek. Aug.

Aster prenanthoides Muhl.; Willd. Sp. Pl. 3: 2046. 1804.
Coll.: Wheeler 518, Lyon 409, Winnebago; Wheeler 582. Crooked Creek. Aug.

Aster lævis L. Sp. Pl. 876. 1753.
Coll.: Wheeler 509, Lyon 435, Winnebago; Wheeler 616, 626, Brownsville. Aug.

Aster sericeus Vent. Hort. Cels. *pl. 33*. 1800.
Coll.: Wheeler 218, Jefferson. June.

Aster ptarmicoides (Nees) T. & G. Fl. N. A. 2: 160. 1841.
Coll.: Lyon 441, Jefferson. Aug.

Aster salicifolius Lam. Encycl. 1: 306. 1783.
Coll.: Wheeler 552, Lyon 400, Jefferson; Lyon 427, Winnebago. Aug.

Aster paniculatus LAM. Encycl. 1: 306. 1783.
Coll.: Wheeler 540, Jefferson; 623, Brownsville. Aug.

Erigeron pulchellus MICHX. Fl. Bor. Am. 2: 124. 1803.
Coll.: Lyon 28, Winnebago. June.

Erigeron annuus (L.) PERS. Syn. 2: 431. 1807.
Coll.: Lyon 84, 420, 432, Winnebago; Wheeler 562, Jefferson. Aug.

Erigeron ramosus (WALT.) B.S.P. Prel. Cat. N. Y. 27. 1888.
Coll.: Wheeler 530, 572, Jefferson. Aug.

Leptilon canadense (L.) BRITTON, in Brit. & Brown, Ill. Fl. 3: 391. *f. 3827.* 1898.
Coll.: Lyon 303, Jefferson. Aug.

Doellingeria umbellata pubens (A. GRAY) BRITTON, in Brit. & Brown, Ill. Fl. 3: 392. 1898.
Coll.: Lyon 399, Jefferson; Wheeler 581, Crooked Creek. Aug.

Antennaria plantaginifolia (L.) RICHARDS. App. Frank. Journ. Ed. 2, 30. 1823.
Coll.: Lyon 23, Winnebago. June.

Gnaphalium obtusifolium L. Sp. Pl. 851. 1753.
Coll.: Lyon 338, 440, 465, Jefferson. Aug.

Polymnia canadensis L. Sp. Pl. 926. 1753.
Coll.: Wheeler 316, Mayville; Lyon 344, Jefferson. July, Aug.

Silphium perfoliatum L. Sp. Pl. Ed. 2, 1301. 1763.
Coll.: Lyon 215, 240, Crooked Creek. July.

Silphium laciniatum L. Sp. Pl. 919. 1753.
Coll.: Wheeler 297, Crooked Creek. July.

Heliopsis helianthoides (L.) B.S.P. Prel. Cat. N. Y. 28. 1888.
Coll.: Wheeler 614, Brownsville. Aug.

Heliopsis scabra DUNAL, Mem. Mus. Paris, 5: 56. *pl. 4.* 1819.
Coll.: Wheeler 330, Crooked Creek. July.

Rudbeckia triloba L. Sp. Pl. 907. 1753.
Coll.: Wheeler 502, Winnebago; 535, Jefferson. Aug.
Not previously reported from Minnesota. Infrequent, edges of thickets.

Rudbeckia hirta L. Sp. Pl. 907. 1753.
Coll.: Wheeler 301, 329, Crooked Creek; 613, Brownsville. July, Aug.

Rudbeckia laciniata L. Sp. Pl. 906. 1753.
Coll.: Lyon 232, Crooked Creek; Wheeler 542, Jefferson. July, Aug.

Ratibida pinnata (VENT.) BARNHART, Bull. Torr. Club, **24**: 410. 1897.
Coll.: Wheeler 374, Crooked Creek. July.

Ratibida columnaris (SIMS) D. DON; Sweet, Brit. Fl. Gard. **2**: 361. 1838.
Coll.: Wheeler 536, Jefferson. Aug.
Not previously reported from eastern Minnesota. Rare, dry banks.

Helianthus atrorubens L. Sp. Pl. 906. 1753.
Coll.: Wheeler 634, Brownsville. Aug.
Not previously reported from Minnesota. The only previous collection known is that of Sandberg, Hennepin Co., Aug., 1889.

Helianthus scaberrimus ELL. Bot. S. C. & Ga. **2**: 423. 1824.
Coll.: Wheeler 445, 528, Jefferson; 579, Crooked Creek. Aug.

Helianthus occidentalis RIDDELL, Suppl. Cat. Ohio Pl. 13. 1836.
Coll.: Wheeler 444, Lyon 322, Jefferson; Wheeler 511, Winnebago. Aug.

Helianthus grosse-serratus MARTENS, Sel. Sem. Hort. Loven. 1839.
Coll.: Wheeler 549, Jefferson. Aug.

Helianthus divaricatus L. Sp. Pl. 906. 1753.
Coll.: Wheeler 566, 576, Jefferson; 630 Winnebago. Aug.

Helianthus tracheliifolius MILL. Gard. Dict. Ed. 8, No. 7. 1768.
Coll.: Wheeler 603, Crooked Creek. Aug.

Helianthus strumosus L. Sp. Pl. 905. 1753.
Coll.: Wheeler 632, Brownsville. Aug.

Helianthus tuberosus L. Sp. Pl. 905. 1753.
Coll.: Wheeler 567, Jefferson. Aug.

Coreopsis palmata NUTT. Gen. **2**: 180. 1818.
Coll.: Lyon 160, Winnebago; 182, Crooked Creek. June, July.

Bidens lævis (L.) B.S.P. Prel. Cat. N. Y. 29. 1888.
Coll.: Wheeler 560, Jefferson. Aug.

Bidens comosa (A. GRAY) WIEGAND, Bull. Torr. Club, **24**: 436. 1897.
Coll.: Wheeler 544, 559, Jefferson; 628, Brownsville. Aug.
Not previously reported from Minnesota. The only previously collected authentic specimen seen from Minnesota is that of Aiton, Minneapolis, Sept., 1890.
Common on the low wet ground throughout.

Bidens frondosa L. Sp. Pl. 832. 1753.
Coll.: Wheeler 541, Jefferson. Aug.

Helenium autumnale L. Sp. Pl. 886. 1753.
Coll.: Wheeler 487, Jefferson. Aug.

Achillea millefolium L. Sp. Pl. 899. 1753.
Coll.: Wheeler 398, Jefferson. July.

Anthemis cotula L. Sp. Pl. 894. 1753.
Coll.: Lyon 269, 284, Jefferson. July.

Chrysanthemum leucanthemum L. Sp. Pl. 888. 1753.
Coll.: Lyon 231, Crooked Creek. July.

Tanacetum vulgare L. Sp. Pl. 844. 1753.
Coll.: Lyon 416, Winnebago. Aug.

Artemisia dracunculoides PURSH, Fl. Am. Sept. 742. 1814.
Coll.: Wheeler 370, Crooked Creek; Lyon 369, 390, Jefferson. Aug.

Artemisia serrata NUTT. Gen. **2**: 142. 1818.
Coll.: Lyon 383, Jefferson. Aug.

Artemisia gnaphalodes NUTT. Gen. **2**: 143. 1818.
Coll.: Wheeler 550, Jefferson; Lyon 419, Winnebago. Aug.

Erechtites hieracifolia (L.) RAF. DC. Prodr. **6**: 294. 1837.
Coll.: Lyon 342, 446, Jefferson; Wheeler 621, Brownsville. Aug.

Mesadenia reniformis (MUHL.) RAF. New Fl. **4**: 79. 1836.
Coll.: Wheeler 273, Crooked Creek. June.

Senecio plattensis NUTT. Trans. Am. Phil. Soc. (II.) **7**: 413. 1841.
Coll.: Wheeler 100, Winnebago. June.
Not previously reported from Minnesota. The only previous known collection in this state is that of Prof. Conway MacMillan from Hennepin county.

Senecio aureus L. Sp. Pl. 870. 1753.
Coll.: Lyon 54, Winnebago. June.

Arctium minus Schk. Bot. Handb. 3: 49. 1803.
Coll.: Wheeler 432, Jefferson. July.

Carduus lanceolatus L. Sp. Pl. 821. 1753.
Coll.: Lyon 242, Crooked Creek. July.

Carduus discolor (Muhl.) Nutt. Gen. 2: 130. 1818.
Coll.: Lyon 377, Jefferson. Aug.

Carduus odoratus (Muhl.) Porter. Mem. Torr. Club, 5: 345. 1894.
Coll.: Herb. Wheeler 25, Winnebago. July.

Description of Plate XXI.

A. Juniper point, Crooked creek valley. Southwest side of bluff dotted with junipers and white birch.

B. Base of bluff, upper Winnebago valley. White pine, juniper and white birch along the upper edge of cliff.

Plate XXII.

A. Western slope of bluff. The woods follow the areas of greatest moisture *i. e.*, the ravines and foot of bluff and the water course in the valley. The shrubs in the valley mark the course of a small creek and are principally willows and dogwoods.

B. Southern slope of bluff showing the steep bare slopes and the thickly wooded ravine. The extreme base of the bluff to the left has been cleared of timber for cultivation.

Plate XXIII.

A. Grove of white birch.

B. Swamp vegetation. *Spathyema* growing in the shade of black ash and yellow birch.

Plate XXIV.

A. Group of coffee trees (*Gymnocladus*).

B. White birch and juniper on side of bluff.

Plate XXV.

A. Slough and island vegetation. *Sagittarias* and *Nelumbo* are the most prominent water plants, and willows and cottonwood on the island in the background.

B. General view of river valley from bluffs on Minnesota side of river. The river channel is on the farther side at the base of the Wisconsin bluffs.

PLATE XXVI.

A. General view of Winnebago valley showing general distribution of forest vegetation. The valley is almost entirely cleared for cultivation.

B. South branch of Winnebago valley. The northern slope of bluff is densely wooded.

PLATE XXVII.

A. *Lilium canadense* growing in moist meadow of creek valley.

B. Pond vegetation. Yellow pond-lily with water grasses and sedges.

PLATE XXI.

THE HELIOTYPE PRINTING CO., BOSTON

PLATE XXIII

THE HELIOTYPE PRINTING CO. BOSTON

THE HELIOTYPE PRINTING CO., BOSTON

PLATE XXV

PLATE XXVI

THE HELIOTYPE PRINTING CO. BOSTON

THE HELIOTYPE PRINTING CO. BOSTON

XXIII. THE SEED AND SEEDLING OF THE WESTERN LARKSPUR (*Delphinium occidentale* Wats.).

FRANCIS RAMALEY.

The seeds of *Delphinium occidentale* vary in color from a yellowish brown to a brownish black. The testa is somewhat irregularly roughened but not pitted or rugose as in many species of the genus, *e. g.*, the official species, *D. staphisagria*. The seeds are three angled with rounded sides and bluntly pointed at the ends. The edges are either merely sharp angled or else the angles project, forming conspicuous wings. (See Fig. 4 and 5.) The seeds are anatropous as in other Ranunculaceæ. The vascular bundle extending from the hilum is small, about 80 microns in diameter. It is situated in the parenchyma of one of the angles. The cells of the bundle are about 2 or 3 microns in diameter, in cross section.

Endosperm.—The body of the seed within the seed-coat consists chiefly of endosperm, the embryo being very small. (See Fig. 5 and 6.) In the endosperm, two distinct portions may be recognized. The inner portion, an ellipsoidal mass, is rich in oily matter. The outer portion contains some oil, but the cubical or prismatic cells of which it is composed are chiefly filled with proteid grains. There is no starch present in any part of the seed.

Embryo.—The embryo, which exhibits slight differentiation, is placed at the micropylar end of the seed. It is embedded in the inner endosperm. The embryo is small, about 0.4 mm. long or one-fifth the length of the entire seed. (See Fig. 5).

Seed-coat.—The testa consists of a large-celled epidermis with a thick cuticle and of four or five layers of large-celled parenchyma. (See Fig. 14.) These cells have yellow or brownish walls and contain only air. They are usually very much flattened in the dry, ripe seed but swell out in seeds which have been soaked in water. The tegmen consists of a single layer of small rectangular cells with thick periclinal and thin anticlinal walls. The cell walls are of a dull brownish color and the cavities are without contents.

Germination takes place in from four to six weeks when seeds are placed under favorable conditions. The cotyledons generally escape from the seed-coat before appearing above ground. This is easily done because by this time the endosperm has been completely used and the seed-coat is likely to be somewhat rotted during the long period of germination.

Morphology of the Seedling.—In the young seedling the cotyledons are small, the blades being generally about 4 mm. in length when they first emerge above the surface of the soil. They increase considerably in size, becoming 8 mm. long and 6 mm. wide. They are ovate, bluntly pointed, with three principal veins from which spring conspicuous secondary veins. The petioles are connate from their bases to a point only a few millimeters from the blades. The structure formed of the united petioles emerges above the surface of the soil in the form of an arch, thus simulating a hypocotyl. (See Fig. 1.) The connate bases of the cotyledons form a dome-shaped structure covering the growing point of the shoot. This structure may be termed the cotyledonary sheath. The development of the foliage leaves causes a rupture of the cotyledonary sheath. Through the opening formed the first and succeeding leaves emerge. (See Figs. 2 and 3.) The cotyledons wither and finally disappear about the sixth week after germination. The first internodes of the stem do not elongate and the sub-aërial portion of the plant consists only of a rosette of long-petioled leaves, until the somewhat scape-like flowering stem is produced. The early foliage leaves show considerable variation in the blade. The first is palmately tri-lobed with narrow sinuses. In some specimens the lobes are pointed, in others rounded. The separate lobes are sometimes rather deeply one- to two-toothed. Later leaves may be similar or may be five-lobed, the lobes generally mucronate, or acute, not rounded. The young seedling of the plant studied resembles that of *Delphinium nudicaule*, first observed by Asa Gray,* and accurately described by Darwin.† Lub-

*Gray. Botanical Text Book, Ed. VI, 1: 22. 1879.

† Darwin. The Power of Movement in Plants, p. 80 (American Edition).

bock,* mentions that in *Delphinium trollifolium* and in *Delphinium consolida* the petioles of the cotyledons are united in the same way.

Anatomy of the Seedling.—As this has apparently not been described for any species of *Delphinium* a somewhat extended account will be given. It may be well to state at the outset that the present writer has studied only the seedling and not the flowering stem. The young root has a thick cortex and small central stele. The endodermis, though thin-walled, is conspicuous in properly stained sections because of the thickened cuticularized spots on the radial walls. The xylem is arranged in two small groups. (See Fig. 7.) In an older portion of the root (Fig. 8) the xylem forms an elongated mass in the center of the stele. Higher up the vascular tissue extending to the cotyledons passes out abruptly on either side at right angles to the longer diameter of the xylem mass. (Fig. 9.) Passing upward the xylem strand divides into six or more bundles as the transition occurs from root to stem. At the same time the cortex becomes thinner. In a cross section at this point (Fig. 10) the cotyledonary sheath is seen surrounding the stem. In a section somewhat higher up (Fig. 11) the bases of the early foliage-leaves may be seen placed alternately. Here the stem abruptly narrows and a rupture of the cotyledonary sheath permits the emergence of the first foliage-leaf. (Figs. 2 and 3). The cotyledonary sheath now becomes smaller, narrowing to form the structure previously spoken of as resembling a hypocotyl. Sections of this structure show that its component petioles are not completely fused at any point (Fig. 12.) A slit-like passage, lined with epidermis, extends upward to the point where the petioles separate completely.

Anatomy of the cotyledonary Sheath.—No difference is to be noted between the outer epidermis and that lining the cavity. It is, in both cases, composed of elongated cells which are square in cross section. There are two vascular bundles, one for each component petiole. These are small but show no peculiarities in structure. The fundamental tissue is a large-celled parenchyma.

Anatomy of the Laminæ of the Cotyledons.—Each lamina has three principal veins which send off numerous branches. The epidermis is composed of thin-walled cells, somewhat

* Lubbock. On Seedlings, 2: 96. 1892.

larger on the upper surface than on the lower. These cells have a very sinuous outline when seen in surface view. Stomata are confined to the lower leaf surface. A loose palisade layer lies next to the upper epidermis. The spongy parenchyma below this has large air cavities. A few short, clavate, unicellular trichomes sometimes occur on the under surface of the leaf.

Anatomy of the foliage leaves.—The leaves have sheathing bases and channeled petioles. In the center of the petiole there is an air cavity. Five or more vascular bundles form a circle outside this cavity. (See Fig. 13.) Each bundle consists of a large mass of xylem, a very small amount of phloëm and, external to this, a small mass of stereom with lignified cell walls. The fundamental tissue is loose parenchyma. No special hypoderma is developed. The epidermis is thin-walled. The leaf laminæ are thin and composed of very loose tissue. The epidermal cells are large and have sinuous outlines. An interesting peculiarity is to be noted in the palisade. The cells of this tissue are frequently branched at the upper end. (See Fig. 15.) This peculiarity was noted, according to Solereder,* by Haberlandt in certain species of allied genera, but that investigator failed to find branched palisade cells in any of the species of *Delphinium* which he studied. The stomata of the foliage leaves are confined to the lower surface of the leaf. A row of short, simple, pointed trichomes is placed along the margin of the leaf and a very few similar trichomes are scattered on the upper surface.

Explanation of Figures, Plate XXVIII.

Figures 1, 2, 3. Seedlings of *Delphinium occidentale* in various stages of development (natural size). In Figures 1 and 2 the united petioles of the cotyledons have the appearance of a hypocotyl. In Figure 2 the first leaf appears as a small projection at the base of the petioles of the cotyledons.

Figure 4. Seed. × 18.

Figure 5. Longitudinal section of seed showing the minute embryo. The dotted ellipse indicates the line of division between the inner, oily portion of the endosperm and the outer part containing aleuron grains. × 18.

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* Solereder. Syst. Anat. der Dicotyledonen, 18, 1899.

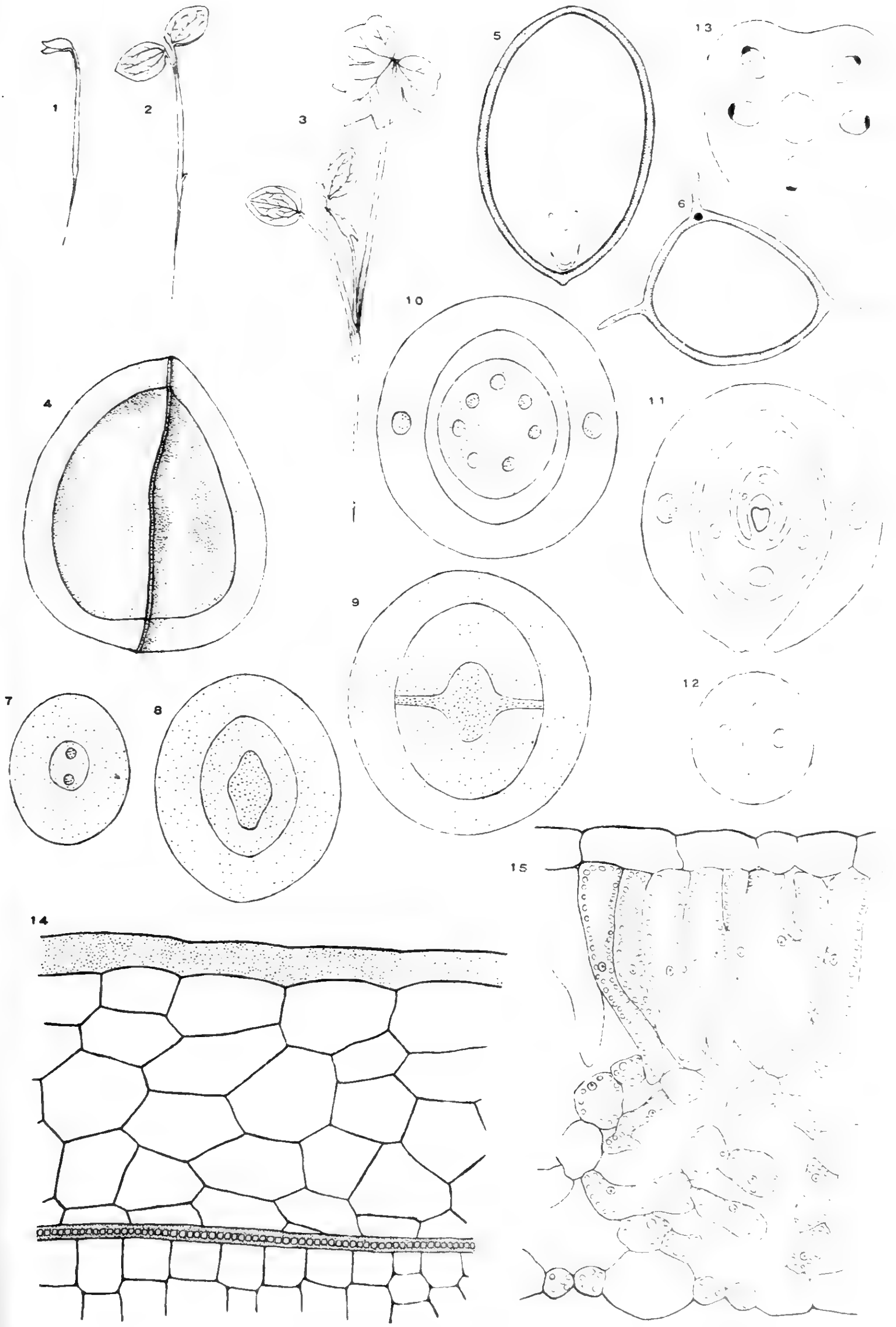

PLATE XXVIII.

Figure 6. Transverse section of seed through the equator. The vascular bundle is in the upper corner. × 18.

Figures 7, 8, 9, 10, 11, 12. All × 18. Diagrams of cross sections of the seedling cut at various levels. Figure 7. The root, thick cortex and small stele with two xylem masses. Figure 8. The root, higher up, a single mass of xylem. "From this the cotyledonary leaf traces extend out horizontally" (Figure 9). Figure 10. The cotyledonary sheath with two vascular bundles encloses the stem. Figure 11. The cotyledonary sheath is ruptured. The sheathing bases of the foliage leaves, arranged alternately, enclose the small triangular apex of the stem. Figure 12. The united petioles of the cotyledons with the slit-like air passage.

Figure 13. Diagram of a cross section of the petiole of the first leaf. The central air cavity is shown, also the circle of vascular bundles (dotted), each with a small amount of stereom (black). × 24.

Figure 14. Section of a seed soaked in water. The epidermis has a very thick cuticle; the parenchyma is large-celled. The layer of small cells with thick walls is the tegmen. The endosperm cells are prismatic (contents not shown). × 270.

Figure 15. Vertical section of the blade of first foliage leaf. Two stomata are shown in the lower epidermis. One of the cells of the palisade layer is branched at the top. Chlorophyll bodies and nuclei are shown in the cells. × 270.

A PRELIMINARY LIST OF MINNESOTA ERYSIPHEÆ.

E. M. FREEMAN.

The collection of fungi in Minnesota has been carried on by the Geological and Natural History Survey of the state at various times for the past fourteen years.* In 1886 Professor J. C. Arthur assisted by Prof. L. H. Bailey and E. W. D. Holway, Esq., made a collection of fungi in St. Louis county especially in the region about Vermillion lake. A list of the plants collected was published in Bulletin No. 3 of the Geological and Natural History Survey of Minnesota. Since that time numerous collections have been made by Dr. A. P. Anderson, Messrs. E. P. Sheldon, C. A. Ballard and others, but lists of the collected plants have not yet been published. The list given below comprises records of all the Erysipheæ which have been collected in Minnesota up to the present time and deposited at the herbarium of the University of Minnesota.

A number of specimens had been identified by Mr. Sheldon and these together with the above mentioned collection of Professor Arthur and his party have in every case been reëxamined so that the writer assumes the sole responsibility of the determinations. The specimens have been compared with such well known exsiccati as Ellis' North American Fungi, de Thümen's Mycotheca Universalis and others. For the sake of completeness the collection made by Professor Arthur and party is incorporated in this list and where the nomenclature has been changed the name published by Professor Arthur is placed in parentheses after the collection citation. In 1884† A. B. Seymour made a few collections along the Northern Pacific Railroad. Speci-

* A list of Minnesota fungi published by Dr. A. E. Johnson in the Bulletins of the Minnesota Academy of Natural Sciences during the years 1876–1879 cannot be considered authentic, since no collection is available for comparison.

† Seymour, A. B. List of Fungi, collected in 1884 along the Northern Pacific Railroad. Proc. Bost. Soc. Nat. Hist. **24**: 182–191. 1889.

mens of these were not left at the University herbarium. No species however are reported by him, that have not been collected by the staff of the survey. Mention of Seymour's collections is appended to each species reported by him.

The nomenclature of Burrill * has been made use of in the list and for full synonymy the reader is referred to the works cited below. Britton and Brown's Illustrated Flora of the United States and Canada has been closely followed in the naming of all host plants.

Of the Erysipheæ, nineteen species in all have been collected, distributed among the genera as follows : *Sphærotheca*, 3 ; *Erysiphe*, 5 ; *Uncinula*, 3 ; *Phyllactinia*, 1 ; *Podosphæra*, 1 ; *Microsphæra*, 6. In field work carried on during such a long period of time and by as many as ten collectors acting independently, it is to be expected that the number of collections of common forms will be increased at the expense of the number of species. A glance at the list given below will show that such has been the case in Minnesota. There are undoubtedly at least a dozen more species of blights in the state, and it is hoped that this list will aid future observations. In citing the district of collection, only the county name is given.

1. **Sphærotheca humuli** (DC.) BURRELL, Bull. Ill. St. Lab. Nat. Hist. 2 : 400. 1887.

On leaves of :

Rubus hispidus L. : St. Louis, July, 1886, Holway 46. (*S. castagnei* Lev.)

Viola sp. indet. : Brown, July, 1891, Sheldon 851.

Humulus lupulus L. : ———,† Sheldon 7020.

2. **Sphærotheca castagnei** LEV. Ann. Sci. Nat. III. 25 : 139. 1851.

On leaves of :

Taraxacum taraxacum (L.) KARST. ; St. Louis (?) ; July, 1886, Holway 276. (Not published in Arthur's report.)

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* Burrill, T. J., and Earle, F. S. Parasitic Fungi of Illinois. Bull. Ill. St. Lab. Nat. Hist. 2. 1887.

Ellis, J. B., and Everhart, B. M. North American Pyrenomycetes, 2–30. 1892.

† Mr. Sheldon's last field note book has not, up to the present time, been found. Consequently the dates of collection, the district and the name of the host plant often cannot be determined. The missing data are indicated as above.

Pedicularis lanceolata Michx.; Lincoln, August, 1891, Sheldon 1522.

Bidens frondosa L.; Lincoln, August, 1891, Sheldon 1516, —— September, 1893, Sheldon 6092, Hennepin, Oct., 1898, Freeman 50.

Seymour reports this species on *Erechtites hieracifolia* and *Nabalus* sp. at Lake Minnetonka.

3. **Sphærotheca mors-uvæ** (Schw.) B. & C. Grev. 4: 158. 1876.

On leaves of:

Ribes floridum L'Her.: St. Louis, July, 188, Holway 84 (*Sphærotheca pannosa* Lev.); Kandiyohi, July, 1892, Frost 249.

4. **Erysiphe cichoracearum** DC. Flore Franc. **2**: 274. 1815.

On leaves of:

Ambrosia artemisiæfolia L.: Hennepin, 1890, MacMillan; ——, Sheldon 7322; ——, Sheldon 6162; ——, Sheldon 6131; Ramsey, Sept., 1898, Freeman 61.

Ambrosia psilostachya DC. Traverse, Sept., 1893, Sheldon 7081.

Ambrosia trifida L.: Pope, Aug., 1891, Taylor 1126; Brown, Sept., 1891; Sheldon 1243; Traverse, Sept., 1893, Sheldon 7086; Goodhue, Aug., 1893, Anderson 727; Ramsey, Sept., 1898, Freeman 62; Hennepin, Sept., 1898, MacMillan.

Heliopsis scabra Dunal.: Kandiyohi, Aug., 1892, Frost 449.

Cnicus sp. indet.: Hennepin, 1890, MacMillan; Traverse, Sept., 1893, Sheldon 7072.

Carduus sp. indet.: ——, Sheldon 7357; Hennepin, 1890, MacMillan.

Aster puniceus L. var. *lucidulus* A. Gray: Lincoln, Aug., 1891, Sheldon 1507.

Aster sp. indet.: Winona, Sept., 1888, Holzinger; Hennepin, Oct., 1898, Freeman 63; Hennepin, Oct., 1892, Sheldon 4123.

Solidago canadensis L.: ——, Sheldon 6082.

Solidago sp. indet.: Hennepin, 1890, MacMillan; Waseca, June, 1891, Taylor 188; Hennepin, Oct., 1891, Sheldon; Goodhue, Aug., 1893, Anderson 814.

Helianthus divaricatus L.: ——, Sept., 1893, Sheldon 6089.

Helianthus decapetalus L.: Brown, July, 1891, Sheldon, 1244.

Helianthus grosse-serratus MARTINS: Traverse, Sept., 1893, Sheldon 7106.

Helianthus scaberrimus ELL.: ——, Sept., 1893, Sheldon 6143; Ramsey, Sept., 1898, Freeman 64.

Helianthus tuberosus L.: Goodhue, Aug., 1893, Anderson 705; Ramsey, Sept., 1898, Freeman 65.

Heilanthus sp. indet.: Traverse, Sept., 1893, Sheldon 7085; Hennepin, 1890, MacMillan; Blue Earth, June, 1891, Sheldon 483; Winona, Sept., 1888, Holzinger; Lincoln, Aug., 1891, Sheldon 1418.

Verbena stricta VENT.: Ramsey, Sept., 1898, Freeman 66.

Verbena urticifolia L.: Chisago, Aug., 1892, Taylor 1639; Hennepin, Aug., 1890, MacMillan; Hennepin, Sept., 1898, Freeman 67.

Verbena hastata L.: Hennepin, Oct., 1892, Sheldon 4128; Pope, Aug., 1891, Taylor 1188; Goodhue, Aug., 1893, Anderson 827; Ramsey, Sept., 1898, Freeman 68.

Verbena sp. indet.: Traverse, Sept., 1893, Sheldon 7030; Carver, July, 1891, Ballard 650; Traverse, Sept., 1893, Sheldon 7071.

Rudbeckia laciniata L.: Hennepin, Sept., 1898, MacMillan.

Senecio aureus L.: Brown, July, 1891, Sheldon 1153.

Hydrophyllum virginicum L.: Blue Earth, June, 1891, Sheldon 203.

Grindelia squarrosa (PURSH) DUNAL: Pipestone, Aug., 1891, Sheldon 1434.

Lappula virginiana (L.) GREENE: Blue Earth, June, 1891, Sheldon 483; St. Louis, July, 1886, Holway 78.

Lappula sp. indet.: Brown, Aug., 1891, Sheldon 1232.

Coreopsis palmata NUTT.: Winona, Sept., 1888, Holzinger.

5. **Erysiphe communis** (WALLR.) FR. Summa. Veg. Scand. 406. 1849.

On leaves of:

Eupatorium ageratoides L.: Hennepin, Oct., 1893, Sheldon 4083.

Lathyrus venosus MUHL.: Winona, Sept., 1888, Holzinger 326; Pope, July, 1891, Taylor 1181; Mille Lacs, July, 1892, Sheldon 2755; Otter Tail, Aug., 1892, Sheldon 3661.

Lathyrus sp. indet. ——, Sheldon 6127.

Œnothera sp. indet.: Hennepin, 1890, MacMillan.

Clematis virginiana L.: Hennepin, 1890, MacMillan.

Anogra albicaulis (PURSH) BRITTON.: Brown, July, 1891, Sheldon 1195.

Strophostyles helvola (L.) BRITTON: Pope, July, 1891, Taylor 1136.

Falcata comosa (L.) KUNTZE: Pope, July, 1891, Taylor 1136.

Oxygraphis cymbalaria (PURSH) PRANTL: Lincoln, Aug., 1891, Sheldon 1357.

Astragalus canadensis L.: Lincoln, Aug., 1891, Sheldon 1423; Hennepin, Sept., 1898, MacMillan.

Aragallus involutus A. Nels.: Lincoln, Aug., 1891, Sheldon 1390.

An undetermined plant of pea family: Traverse, Sept., 1893, Sheldon 7257.

Thalictrum purpurascens L.: Chisago, Sept., 1893, Sheldon 6188.

Thalictrum sp. indet.: Cass. Aug., 1893, Anderson 706.

Onagra biennis (L.) SCOP. ——, Sept., 1893, Sheldon 6146.

Anemone virginana L.: Traverse, Sept., 1893, Sheldon 7089.

Lotus americanus (NUTT.) BISH.: Big Stone, Sept., 1893, Sheldon, Traverse, Sept., 1893, Sheldon 7201.

Polygonum aviculare L.: Ramsey, Sept., 1898, Freeman 51.

Seymour reports *E. communis* on *Lathyrus?* at Lake Minnetonka.

6. **Erysiphe aggregata** (PECK) FARLOW, Bull. Bussey, Inst. 2: 227. 1878.

On leaves of:

Alnus incana (L.) WILLD.: St Louis, July, 1886, Holway 51.

7. **Erysiphe galeopsidis** DC. Flore Franc. **6**: 108. 1815.

On leaves of:

Stachys palustris L.: Lincoln, Aug., 1891, Sheldon 1572; Lincoln, Aug., 1891. Sheldon 1261.

Seymour reports this species on *Stachys palustris* at Detroit, Minnesota.

8. **Erysiphe graminis** DC. Flore Franc. **6**: 106. 1815.

On leaves of:

Poa pratensis L.: Waseca, June, 1891, Taylor 228. No perithecia found. Conidial stage (*Oidium monthoides* Link) only is present.

9. **Uncinula salicis** (DC.) WINT. Die Pilze **1**^{2}: 40. 1887.

On leaves of:

Salix sp. indet.: Winona, Sept., 1888, Holzinger; Chisago, Sept., 1891, Sheldon 4263; Traverse, Sept., 1892, Sheldon 7172; Traverse, Sept., 1892, Sheldon 7013; Chisago, Aug., 1892, Taylor 1634; Otter Tail, July, 1892, Sheldon 3936; Hennepin, Oct., 1893, Sheldon 4093; McLeod, Aug., 1. J. McElligott; Traverse, Sept., 1893, Sheldon 7069; Ramsey, Sept., 1898, Freeman 60.

Salix bebbiana SARG.: Chisago, Sept., 1891, Sheldon 4246.

Salix myrtilloides L.: Otter Tail, July, 1892, Sheldon 3573½.

Salix discolor MUHL.: Hennepin, Oct., 1893, Sheldon 4089.

Populus deltoides MARSH.: Hennepin, July, 1889, Sheldon; Hennepin, Oct., 1889, MacMillan; Wabasha, Sept., 1893, Edna Porter.

Populus grandidentata MICHX.: Hennepin, 1890, MacMillan.

Populus tremuloides MICHX.: Goodhue, Aug., 1893, Anderson 707.

Populus sp. indet. Hennepin, Oct., 1889, MacMillan.

Seymour reports *U. salicis* on *Salix* sp. at Lake Minnetonka.

10. **Uncinula clintonii** PECK, Rep. N. Y. St. Mus. **25**: 96. 1873. Trans. Alb. Inst. **7**: 216.

On leaves of:

Tilia americana L.: Winona, Sept., 1888, Holzinger.

11. **Uncinula necator** (SCHW.) BURRILL. N. A. Pyren. 15. 1892.

On leaves of:

Parthenocissus quinquefolia (L.) PLANCH.: Ramsey, Sept., 1898, Freeman 59; Hennepin, Sept., 1898, F. K. Butters.

12. **Phyllactinia suffulta** (REB.) SACC. Mich. **2**: 50. 1880.

On leaves of:

Tilia sp. indet.: Le Sueur, June, 1891, Sheldon 64. Seymour reports this species on *Betula* ? at Lake Minnetonka.

13. **Podosphæra oxyacanthæ** (DC.) D. BY. Beitr. Morph. und Phys. der Pilze, Part 3, 48. 1870.

On leaves of:

Prunus sp. indet.: Hennepin, 1890, MacMillan.

Cratægus (?) sp. indet.: Le Sueur, June, 1891, Sheldon 62. ——; Wabasha, Sept., 1893, Edna Porter.

14. **Microsphæra russellii** CLINTON, Rep. N. Y. St. Mus. **26**: 80. 1874.

On leaves of:

Oxalis stricta L.: Winona, Aug., 1888, Holzinger.

15. **Microsphæra ravenelii** BERK. Grev. **4**: 160. 1876.

On leaves of:

Lathyrus sp. indet.: Goodhue, Aug., 1892, Ballard 1152; Goodhue, Aug., 1893, Anderson 708.

Seymour reports *M. ravenelii* Berk. on *Lathyrus* ? at Detroit, Minn.

16. **Microsphæra quercina** (SCHW.) BURRILL, Bull. Ill. St. Lab. Nat. Hist. **2**: 424. 1887.

On leaves of:

Quercus macrocarpa MICHX.: Hennepin, 1890, MacMillan; Ramsey, Sept., 1898, Freeman 52.

17. **Microsphæra symphoricarpi** HOWE, Bull. Torr. Club, **5**: 3. 1874.

On leaves of:

Symphoricarpos sp. indet.: Hennepin, 1890, MacMillan; Waseca, June, 1891, Taylor 615; Goodhue, Aug., 1893, Anderson 815; ——, Sheldon 7262; ——, Sheldon 7392.

Symphoricarpos racemosa MICHX.: Traverse, Sept., 1893, Sheldon 7084.

Symphoricarpos symphoricarpos (L.) MACM. Traverse, Sept., 1893, Sheldon 7083.

Symphoricarpos occidentalis HOOK.: Ramsey, Sept., 1898, Freeman 53.

18. **Microsphæra diffusa** C. & P. Journ. of Bot. **11**: 1872. Rep. N. Y. St. Mus. **25**: 95. 1873.

On leaves of:

Lespedeza violacea (L.) PERS.: Winona, Sept., 1889, Holzinger.

Lathyrus sp. indet.: Hennepin, 1890, MacMillan.

Meibomia canadensis (L.) KUNTZE.: Lincoln, Aug., 1891, Sheldon 1521; ——, Sept., 1893, Sheldon 6105.

Seymour reports *M. diffusa* on *Lespedeza capitata* at Brainerd.

19. **Microsphæra alni** (DC.) WINT. Die Pilze **1**^{2}: 38. 1887.

On leaves of:

Lonicera sp. indet.: St. Louis, July, 1886, Holway 242, (*M. dubyi* Lev.); Ramsey, Sept., 1898, Freeman 56.

Lonicera hirsuta Eaton: St. Louis, July, 1886, Holway 150, (*M. dubyi* Lev.).

Syringa vulgaris L.: Hennepin, July, 1889, Sheldon; Hennepin, Oct., 1891; ——, Sheldon 5806; Goodhue, Aug., 1893, Anderson 714.

Alnus sp. indet.: Hennepin, 1890, MacMillan.

Viburnum lentago L.: Waseca, June, 1891, Sheldon, 506½; Case, Aug., 1893, Anderson 668; Ramsey, Sept., 1898, Freeman 54.

Viburnum sp. indet.: Ramsey, Sept., 1898, Freeman 55.

Lonicera dioica L.: Goodhue, Aug., 1893, Anderson 753.

Corylus americana WALT.: Ramsey, Sept., 1898, Freeman 57.

Tilia americana L. !: Hennepin, Oct., 1898, Freeman 58.

Seymour reports this species on *Ceanothus americanus* at Brainerd and on *Syringa vulgaris* and *Betula* at Lake Minnetonka.

NATIVE AND GARDEN DELPHINIUMS OF NORTH AMERICA.

K. C. Davis.

The name *Delphinium* (Linn. Sp. Pl. 530, 1753) is from the Greek *delphin*, a dolphin, from the resemblance of the flower, The common name is Lark Spur.

It is a genus of beautiful, hardy plants, annual or perennial, erect, branching herbs. Leaves palmately lobed or divided; large, irregular, showy flowers in a raceme or panicle; sepals petal-like, five, the posterior one prolonged into a spur; petals two or four, small, the two posterior ones usually spurred, the lateral or lower ones small if present; the few carpels always sessile, forming many-seeded follicles.

There are probably more than 200 species. In fact Huth's last complete monograph recognized 198 species besides a number of doubtful ones. The following treatment includes the native and cultivated *Delphiniums* of North America, 52 species and many varieties and garden forms. Thirty species are native of America north of Mexico, thirteen of which are used in gardens. Thirteen Old World species have been introduced into the American trade. Nine Mexican species are distinct, and none of them are in use. The mark (†) after a description indicates which plants are not used in the trade. Four species are of much greater popularity than the others: the annual *D. Ajacis*, and the perennials *D. grandiflorum*, *D. hybridum*, and *D. formosum*. The last three have been especially prolific in giving us new garden forms.

In presenting this paper I wish to extend thanks to those who have materially helped me, especially to those who have freely given me the privilege of examining numerous specimens: Dr. J. N. Rose, Professor E. L. Greene, Dr. N. L. Britton and Dr. B. L. Robinson.

The recent extended articles on the genus are: A. Gray, "An attempt to Distinguish Between the American Delphiniums," Bot. Gaz. **12**: 49–54, 1887; and Syn. Fl. **1**: 45–52, 1895. E. Huth, "Monog. Gattung Delphinium," in Engl. Bot. Jahrb. **20**: 322–499, 1895. K. C. Davis, in Bailey's Cyclopedia of American Horticulture.

Synopsis of Species of Delphinium.

A. Roots annual; petals only 2, united; follicles 1.
  B. Follicles pubescent, ½ to 1½ inches long...............1. *Ajacis*.
  BB. Follicles glabrous, ¼ to ½ inch long..................2. *consolida*.
AA. Roots perennial; petals 4; follicles 3 to 5.
  B. Sepals red.
    C. Plant glabrous; seeds smooth........................3. *nudicaule*.
    CC. Plant partly pubescent; seeds thin winged.....4. *cardinale*.
  BB. Sepals greenish yellow, yellow, or sometimes marked with blue.
    C. Inflorescence and leaves densely hairy.
      D. Flowers not tinged with blue..................5. *viridescens*.
      DD. Flowers sordid white tinged with blue...6. *Californicum*.
    CC. Inflorescence and leaves glabrescent or soon becoming so.
      D. Mature follicles densely hairy..................7. *Przewalskii*.
      DD. Mature follicles smooth or sulcate.
        E. Seeds with plates or scales in transverse rows...8. *Zalil*.
        EE. Seeds winged and somewhat wrinkled...........9. *viride*.
  BBB. Sepals blue, or varying to white, or white.
    C. Species native north of Mexico, or introduced from Old World.
      D. Height 1½ feet or less.
        E. Natives of America north of Mexico.
          F. Petioles dilating and somewhat sheathing at the base.
            G. Stem lax; follicles glabrous or becoming so.
              H. Roots fascicled and thickened but not tuberiform. 10. *bicolor*.
              HH. Roots fasciculately tuberous, or grumose. 11. *decorum*.
            GG. Stem rather stout, erect: follicles pubescent.
              H. Length of sepals about equalling the petals.
                I. Seeds winged at the angles........12. *hesperium*.
                II. Seeds scaly and bur-like............13. *Hanseni*.
              HH. Length of sepals much greater than petals. 14. *variegatum*.
          FF. Petioles hardly dilating at the base.

G. Coats of seeds smooth; roots fasciculately tuberous. 15. *tricorne.*

GG. Coats of seeds winged or wrinkled, roots not tuberous, but in some grumose.

H. Roots not grumose.

I. Sepals shorter than the spur.

J. Leaves thickish; racemes long. 16. *Andersonii.*

JJ. Leaves not thick; racemes shorter; flowers smaller............................17. *Parishii.*

II. Sepals as long as spur, much surpassing petals. 18. *Parryi.*

HH. Roots coarsely granular or grumose; carpels always 3, seeds wing-margined.

I. Pedicels longer than the flowers; follicles spreading when mature..................19. *Menziesii.*

II. Pedicels shorter than flowers; follicles spreading only at tips.................20. *pauciflorum.*

EE. Natives of Asia but introduced to American gardens.

F. Sepals somewhat persistent; bractlets opposite, lanceolate, entire, near the flower.........21. *Brunonianum.*

FF. Sepals deciduous; bractlets alternate, linear, or linear-lobed, distant from flower.........22. *Cashmirianum.*

DD. Height more than 1½ feet (except in a few cases).

E. Seeds wrinkled or scaly, hardly winged (except in 28 and 29); all native of the United States except 23.

F. Follicles always 3.

G. Upper petals violet.....................23. *altissimum.*

GG. Upper petals yellowish, or yellow with blue tips.

H. Inflorescence a crowded, erect, pyramidal raceme. 24. *exaltatum.*

HH. Inflorescence open and somewhat branching; pedicels long and slender...............25. *Treleasi.*

FF. Follicles commonly varying from 3 to 5 on each plant.

G. Stems more or less leafy.

H. Sepals and spurs blue.

I. Stem leafy; radical leaves few. 26. *Carolinianum.*

II. Stem leaves mostly near the base; radical leaves many.

J. Root a flattish tuber...........27. *Oreganum.*

JJ. Root woody-fibrous......... .....28. *Geyeri.*

HH. Sepals and spurs chiefly white..29. *camporum.*

GG. Stem leafless.

H. Petioles of root leaves much longer than blades. 30. *scaposum.*
HH. Petioles of root leaves nearly equalling blades. 31. *uliginosum.*
EE. Seeds decidedly winged.
F. Upper petals white, never yellow.....32. *trolliifolium.*
FF. Upper petals often yellow or yellowish.
G. Species from Old World introduced into gardens; follicles always 3.
H. Lower petals deep blue, 2-lobed, yellow-bearded. 33. *elatum.*
HH. Lower petals bright blue, entire, undulate or slightly 2-lobed.
I. Flowers very large; spurs 9 to 10 lines long. 34. *grandiflorum.*
II. Flowers smaller; spurs 5 to 8 lines long. 35. *cheilanthum.*
GG. Species from west of the Rockies; follicles always 3.
H. Plant glabrous, at least in lower part.
I. Roots fascicled, not tuberous nor grumose.
J. Follicles pubescent............36. *scopulorum.*
JJ. Follicles glabrous...............37. *glaucum.*
II. Root tuberous or grumose.
J. Lower pedicels rather spreading, longer than the spurs.
K. Sepals equal to spur in length. 38. *glaucescens.*
KK. Sepals shorter than the spur. 39. *Nuttallii.*
JJ. Lower pedicels and others appressed, shorter than spurs.............................40. *distichum.*
HH. Plant pubescent throughout.........41. *simplex.*
EEE. Seeds scaly; lower petal 2-lobed; Old World type.
F. Petioles hardly dilating at base, not sheathing; lower petals yellow bearded ....42. *formosum.*
FF. Petioles sheathing at base; beard on lower petals not yellow.
G. Flowers in loose panicles..........43. *Maackianum.*
GG. Flowers in dense racemes............44. *hybridum.*
CC. Natives of Mexico, not introduced to American gardens.
D. Carpels puberulent to hairy at first.
E. Plant glandular-hispid above.................45. *Madrense.*
EE. Plant not glandular-hispid in upper parts.

F. Lower petals provided with a scale-like appendage at base.
G. Stamens puberulent....................46. *bicornutum.*
GG. Stamens glabrous.
H. Upper petals tipped with yellow..47. *Ehrenbergi.*
HH. Upper petals not tipped with yellow.
48. *pedatisectum.*
FF. Lower petals with appendages wanting or obscure.
G. Leaves pubescent or villose.
H. Upper petals blue...................49. *latisepalum.*
HH. Upper petals yellow with blue tips.
50. *tenuisectum.*
GG. Leaves glabrous. ....51. *leptophyllum.*
DD. Carpels glabrous.................................52. *Wislizeni.*

1. **D. Ajacis** LINN. Sp. Pl. 531. 1753.
D. consolida SIBTH. & SM. Fl. Græca, Prod. **1**: 370. 1806. Not L.
D. ornatum BOUCHÉ, in Bot. Zeit. **1**: 26. 1843.
D. pubescens GRISEB. Spicil. Fl. Rumel. **1**: 319. 1843. Not DC.
Ceratosanthus ajacis SCHUR. Enum. Pl. Transs. 30. 1866.
? *D. addendum* MCNAB. in Trans. Bot. S. Edinb. **9**: 335. 1868.

An erect annual about 18 inches high with a few spreading branches: leaves of stem sessile, deeply cut into fine linear segments; root-leaves similar but short-petioled: flowers showy, blue or violet, varying to white, more numerous than in *D. consolida*, in a spicate raceme; petals 2, united; calyx-spur about equalling the rest of the flower: but one follicle, pubescent; seeds with wrinkled, broken ridges. May to Aug. Europe. Fl. Græca, *t. 540.* Rev. Hort. 1893, p. 228.

2. **D. consolida** LINN. Sp. Pl. 530. 1753.
D. segetum LAM. Fl. Fr. **3**: 325. 1778.
D. monophyllum GILIB. Fl. Lithuan. **2**: 287. 1781.
D. versicolor SALISB. Prod. 375. 1796.
Ceratosanthus consolida SCHUR. Verh. Sieb. Ver. Naturf. 46. 1853.

An erect, hairy annual, 1 to 1½ feet high: leaves similar to *D. Ajacis:* flowers few, loosely panicled, pedicels shorter than the bracts, blue or violet or white; petals 2, united: follicle 1, glabrous; seeds with broken, transverse ridges. June to Aug. Europe. Baxter Brit. Bot. 4. *t. 297*. Rev. Hort. 1893, p. 228 (var. *ornatum candelabrum*).

3. **D. nudicaule** TORR. & GRAY, Fl. **1**: 33. 1838.
D. sarcophyllum HOOK. & ARN. Bot. Beech. 317. 1841.
D. decorum var. *nudicaule* HUTH, Delph. N. Am. 9. 1892.
D. peltatum HOOK. ex. Huth, Bot. Jahrb. **20**: 449. 1895.

Stem 1 to 1½ feet high, glabrous, branched, few-leaved: leaves rather succulent, 1 to 3 inches across, lobed to the middle or farther 3 to 7 times, the secondary lobes rounded and often mucronate; petioles 3 to 5 inches long, dilated at the base: flowers panicled; sepals bright orange-red, obtuse, scarcely spreading, shorter than the stout spur; petals yellow, nearly as long as sepals; spurs long and funnel-form: follicles 3, spreading and recurved, soon becoming glabrous; seeds thin-winged. April to July. Along mountain streams, Northern California. Bot. Mag. 5819. Flor. des Serr. **19**: 1949. Revue Hort. 1893, p. 259. Marsh, Hot Springs near Santa Rosa, Calif., a pubescent form with thicker leaves. Collected by Coville, May, 1884.

4. **D. cardinale** HOOK. Bot. Mag. *t. 4887*. 1855.
D. coccineum TORR. Pac. Ry. Rep. **4**: 62. 1857.
D. flammeum KELLOGG, in Proc. Calif. Acad. **2**: 22. 1863.

Stem erect, 2 to 3½ feet high, partly pubescent: leaves smooth, fleshy, deeply 5-parted, the parts cut into long, linear lobes: elongated, many-flowered raceme, flowers bright red with petal limbs yellow: follicles glabrous, usually 3; seeds smooth. July to Aug. California. Gartenflora, 208. Flor. des Serr. 11, p. 63. *t. 1105*. Garden **19**: 273.

5. **D. viridescens** LEIBERG, Proc. Biol. Soc. Wash. **11**: 39. 1897.

Roots fascicled not tuberous: plant 5 feet high, pubescent, especially above: lower stem-leaves often 3-parted and again 3–5-lobed and toothed; upper leaves dissected into narrow lobes; leaves all thin; pedicels slender, short, appressed; a narrow bractlet near the base or half way up, and a pair very near the flower: inflorescence and follicles very hairy: flowers cream to greenish-yellow, small; spurs nearly horizontal, longer than the sepals, and as long as the upper pedicels. May to July. Type near Peshaston and Wenatchee, Okanogan Co., Wash., 1500 feet (†).

6. **D. Californicum** TORR. & GRAY, Fl. **1**: 31. 1838.
D. exaltatum HOOK. & ARN. Bot. Beech. 317. 1841. Not Ait.
D. exaltatum var. *Californicum* HUTH, Delph. N. Am. 11. 1892.
D. Californicum var. *scapigerum* HUTH, Bot. Jahrb. **20**: 451. 1895.
? *D. virescens* RYDB. Bull. Torr. Club, **26**: 385. 1899. (Fragment only.)

Stem stout, 2 to 8 feet high; lower leaves very large, deeply cleft, divisions broad wedge shaped; upper with narrower divisions and lanceolate lobes: racemes dense: flowers sordid whitish with tinges of blue; sepals and spur each about ⅓ inch long: follicles much like those of *D. exaltatum*. Dry places. Monterey to Mendocino Co., Calif. (†).

Var. **laxiusculum** HUTH, Bot. Jahrb. **20**: 451. 1895.
Inflorescence very loose and open. San Francisco region and northern Mexico.

7. **D. Przewalskii** HUTH, Bot. Jahrb. **20**: 407. 1895.
D. Przewalskianum HORT.

Nearly glabrous, often branched at base, erect, varying much in height: leaves 3 to 5 times deeply parted; parts divided into narrow obtuse lobes: flowers clear yellow, or sometimes tipped with blue, spur equalling the sepals: follicles 3, densely hairy. July to Aug. Asia.

8. **D. Zalil** AIT. & HEMS. Trans. Linn. Soc. II, **3**: 30. 1888.
D. hybridum var. *sulphureum* HORT.

Stem nearly simple, erect, 1 to 2 feet high, rather glabrous or becoming so: leaves of several narrow, linear lobes, dark green, petioles not dilating at the base: flowers large, light yellow, in long racemes: follicles 3, longitudinally ribbed and furrowed; seeds with transverse, fibrous plates. June to July. Persia. Bot. Mag. 7049. Garden **50**: 1094; **54**: 347. Gard. Chron. III, 20, 247.

9. **D. viride** Wats. Proc. Am. Acad. **23**: 268. 1888.

Root rather thick, branching: plant glaucous, about 2 feet high; stems glabrous: leaves pubescent, with segments acutely lobed, upper ones more deeply divided and segments narrower: racemes open, few-flowered; pedicels 1 to 2 inches long, glabrous or somewhat pubescent; sepals yellowish green, much shorter than the stout spur; petals purple, shorter than the sepals, lower ones entire or cleft, villous: follicles 3, not spreading, very finely pubescent; seeds large, coats dark, wrinkled and somewhat winged at the ends. Gravelly bluffs, east base of Sierra Madre, Chihuahua, Mex. (†).

10. **D. bicolor** Nutt. Journ. Acad. Phila. **7**: 10. 1834.

D. Menziesii Gray, Proc. Acad. Phila. **1863**: 57. Not DC.

D. Menziesii var. *Utahense* Wats. Bot. King Exp. 12. 1871.

Erect, rather stout, ½ to 1 foot high, from fascicled roots: leaves small, thick, deeply parted, and divisions cleft except perhaps in the upper leaves, segments linear: obtuse raceme rather few-flowered; the lower pedicels ascending 1 to 2 inches: spur and sepals nearly equal, ½ inch long or more, blue; upper petals pale yellow or white, blue veined; lower petals blue: follicles glabrous or becoming so. May to Aug. Dry woods. Colorado, west and north to Alaska.

Var. **Montanense** Rydb. Mem. N. Y. Bot. Gard. **1**: 157. 1900.

Plant glandular-pilose; leaves thicker than in the type. Region of Helena and southward into Yellowstone Park (†).

Var. **Nelsonii** n. var. *D. Nelsoni* Greene, Pitt. **3**: 92. 1896.

Roots sometimes slightly fascicled-tuberiform: lowest leaves long-petioled: seeds winged as in the type. Southern Wyoming to middle Colorado (†).

Var. **cognatum** n. var.

D. cognatum Greene, Pitt. **3**: 14. 1896.

Much like the type but the root leaves with very broad segments, plant glabrescent, or hairy on the flowers: sepals narrower than the type, spurs often markedly incurved: follicles 3, glabrous. It is also much like *D. Andersonii*, but has some stem leaves, and the flowers are different. Western Humboldt Mts., Nevada (†).

Var. **glareosum** n. var.

D. glareosum GREENE, Pitt. **3**: 257. 1898.

Rootstock thick, either simple or branched: plant 3 to 8 inches high, with 1 to 3 stem leaves: follicles 3 to 5, glabrous or nearly so. Summit of Mt. Steele, Wash. (†).

11. **D. decorum** FISCH. & MEY. Ind. Sem. Hort. Petrop. **3**: 33. 1837.

D. hesperium HUTH, Bot. Jahrb. **20**: 446. 1895.

Stem slender and weak, ½ to 1½ feet high, smooth or nearly so: leaves few, bright green, upper ones small, 3–5-parted into narrow lobes, lower and radical ones somewhat reniform in outline and deeply 3–5-parted, lobes often differing widely: flowers in a loose raceme, or somewhat panicled; sepals blue, ½ inch long, equalling the spurs; upper petals at least tinged with yellow: follicles 3, thickish, glabrous; seeds rugose, not winged. Spring. Calif. Bot. Reg. **26**: 64.

Var. **gracilentum** n. var.

D. gracilentum GREENE, Pitt. **3**: 15. 1896.

Differs from the type chiefly in the radical leaves, which are larger, deeply about 5-parted or lobed, the lobes mostly oval or oblong, obtuse and entire, apiculate: pedicels often filiform. Foothills of Sierra Nevada in California (†).

Var. **patens** GRAY, Bot. Gaz. **12**: 54. 1887.

D. patens BENTH. Pl. Hartw. 296. 1848.

D. tricorne var. *patens* HUTH, Delph. N. Am. 13. 1892.

Stem erect: racemes compact: flowers small, sepals a third to a half inch long, upper petals often deeply lined with blue; seeds somewhat winged. Siskiyou Co. to southern California (†).

12. **D. hesperium** GRAY, Bot. Gaz. **12**: 54. 1887.

D. Menziesii var. *ochroleucum* TORR. & GRAY, Fl. **1**: 31. 1838.

D. azureum TORR. & GRAY, Fl. **1**: 660. 1840. In part.

D. azureum & *D. simplex* HOOK. & ARN. Bot. Beech. 317. 1841.

D. simplex WATS. Bot. Calif. **1**: 10. 1876.

Roots fascicled, short, some of them fusiform, 2 feet high; stem and leaves puberulent, or hairy below: leaves rather small, much dissected into narrow parts: racemes long, many flowered;

flowers violet-purple varying to whitish, sometimes reddish purple; sepals less than ½ inch long, about equalled by the petals and by the spur; upper petals lined and bordered with blue; pedicels erect in fruit, lowest ones about 1 inch long, others much shorter: follicles 3 to 5, short-oblong, puberulent, ½ inch or less long; seeds black with broad light wings at the angles. West Oregon south to Monterey, Calif. (†).

Var. **recurvatum** n. var.

D. recurvatum GREENE, Pitt. **1**: 285. 1889.

Upper petals yellow, not bordered nor lined with blue. Calif. (†).

13. **D. Hanseni** GREENE, Pitt. **3**: 94. 1896.

D. hesperium var. *Hanseni* GREENE, Fl. Fr. 304. 1892.

D. Hanseni var. *arcuatum* GREENE, Pitt. **3**: 94. 1896.

Closely allied to *D. hesperium*, but very slender: racemes dense but lax: flowers smaller than that type and of a much lighter blue; seeds densely scaly, giving a white, bur-like appearance. Amador Co., Calif. (†).

14. **D. variegatum** Torr. & Gray, Fl. **1**: 32. 1838.

D. grandiflorum var. *variegatum* HOOK. & ARN. Bot. Beech. 317. 1841.

D. decorum BENTH. Pl. Hartw. 295. 1848. Not Fisch. & Mey.

Root, stem and leaves like *D. hesperium*: flowers larger, only few in a raceme; sepals much surpassing the petals: follicles like that species or longer. Monterey, Calif., to the upper Sacramento valley. Common along streams, etc. Well worth introduction to gardens (†). *D. Macounii* GREENE, in Herb. (Macoun no. 18,078, Geo. Surv. Canada) is a low weak form or variety with deeper, less fascicled roots. Rockies. Lat. 39° 40′.

Var. **apiculatum** GREENE, Fl. Fr. 304. 1892.

D. apiculatum GREENE, Pitt. **1**: 285. 1889.

Leaf segments broader: flowers more numerous (†).

Var. **Blochmanæ** n. var.

D. ornatum GREENE, Fl. Fr. 304. 1892. Not Bouché.

D. Blochmanæ GREENE, Erythea, **1**: 247. 1893.

Leaf segments long and linear: sepals narrower than the type, light blue or white; petals with crisp margins. Nipowa, Calif. Specimens at Berkeley (†).

Var. **Emiliæ** n. var.

D. Emiliæ GREENE, Erythea, **2**: 120. 1894.

Plants often 3 feet high: racemes elongated: flowers usually more numerous than in the type. Open places near the head of Knight's Valley, Sonoma Co., Calif. (†).

15. **D. tricorne** MICHX. Fl. **1**: 314. 1803.

D. flexuosum RAF. Ann. Nat. **1**: 12. 1820.

D. aconitifolium MUHLENB. ex Huth, Bot. Jahrb. **20**: 445. 1895.

Stem succulent, about 1 foot high: leaves 3–5-parted with 3–5-cleft linear lobes; petioles smooth, hardly dilating at the base: flowers large, blue, rarely whitish; upper petals sometimes yellow, with blue veins; lower ones white-bearded; sepals nearly equalling the spur: follicles 3 or 4, very long, becoming glabrous, strongly diverging; seeds smooth. May. Northern States. Lodd. Bot. Cab. **4**: 306. Very beautiful and much used.

16. **D Andersonii** GRAY, Bot. Gaz. **12**: 53. 1887.

D. decorum var. *Nevadense* WATS. Bot. Calif. **1**: 11. 1876. In part.

D. Menziesii WATS. Bot. King Exp. 1871. Not DC.

D. tricorne var. *Andersonii* HUTH, Delph. N. Am. 13. 1892.

Stem erect, robust, nearly glabrous, 1½ feet high: leaves rather small, thickish, cuneate divisions, lobes obtuse, short: racemes long, dense: flowers blue; sepals ½ inch long, shorter than the spur: follicles 3 to 5, about ½ inch long, not recurving; seeds winged. Western Nevada to mountains of California (†). *D. Sonnei* GREENE, Pitt. **3**: 264, 1897, is a slender, weak form, from California (†).

17. **D. Parishii** GRAY, Bot. Gaz. **12**: 53. 1887.

Several stemmed, much like the following, but with racemes and flowers smaller: sepals oblong, ¼ to ⅓ inch long, hardly surpassing the petals, shorter than the spur; upper petals yellowish: seed-coats transversely wrinkled; margin broad, winglike. Southeastern California, southward into Lower California (†).

18. **D. Parryi** GRAY, Bot. Gaz. **12**: 53. 1887.

Much like the last: leaves not thick, divisions or lobes few and linear: sepals oval, over ½ inch long, much surpassing the petals, fully as long as the spur: follicles as in the last; seeds with loose coats, folded at the angles forming wing-like processes. Southern California (†).

19. **D. Menziesii** DC. Syst. **1**: 355. 1818.

D. pauperculum GREENE, Pitt. **1**: 284. 1889.

Plant sparingly pubescent: stem simple, slender, ½ to 1½ feet high, few-leaved: leaves small, 3–5-parted, the divisions mainly cleft into linear or lanceolate lobes; petioles hardly dilating at the base: flowers in simple conical racemes; sepals blue, somewhat pubescent outside, nearly equalling the spurs in length; upper petals yellowish: follicles 3, pubescent or sometimes glabrous; seeds black-winged on the outer angles. April to June. On hills, California and northward to Alaska. Bot. Reg. **14**: 1192.

20. **D. pauciflorum** NUTT. ex Torr. & Gray, Fl. **1**: 33. 1838.

D. Nuttallianum PRITZ. in Walpers Rep. **2**: 744. 1843.

D. Menziesii var. *pauciflorum* HUTH, Bot. Jahrb. **20**: 445. 1895.

Stem slender, nearly glabrous, ½ to 1 foot high; oblong or fusiform fasciculate-tuberous roots: leaves small, parted into narrow linear lobes; petioles not dilating at base: flowers and fruit similar to those of *D. Menziesii*, but on shorter pedicels. May to June. Colorado to Washington and California.

Var. **Nevadense** GRAY, Syn. Fl. **1**: 50. 1895.

D. decorum var. *Nevadense* WATS. Bot. Calif. **1**: 11. 1876. In part.

Leaves much dissected: racemes with spreading pedicels: flowers often pinkish purple; sepals longer than in the type but shorter than the spur: follicles much like the type. Sierra Nevadas, above Cisco, and in Plumas Co., Calif., into Nevada (†).

Var. **depauperatum** GRAY, Bot. Gaz. **12**: 54. 1887.

D. tricorne var. *depauperatum* HUTH, Delph. N. Am. 13. 1892.

Stem leaves few, lobes ovate to lanceolate: racemes fewer flowered than in the type and in the preceding variety. Northwestern Nevada into Oregon (†).

21. **D. Brunonianum** Royle, Ill. Bot. Himal. 56. 1839.
D. moschatum Munro ex Hook. f. & Thoms. Fl. Ind. 53. 1858.

Stems erect, ½ to 1½ feet high: plant somewhat pubescent: upper leaves 3-parted, lower ones reniform, 5-parted, segments deeply cut, musk scented: flowers large, light blue with purple margins, center black; spur very short; sepals 1 inch long, membranous and often clinging until the fruit is mature: follicles 3 or 4, villose. June to July. China. Revue Belg. **1863**: 34. Bot. Mag. 5461.

22. **D. Cashmirianum** Royle, Ill. Himal. 55. 1839.

Plant pubescent, not very leafy: stem simple, erect, slender, 10 to 18 inches high: root leaves orbicular, 2–3 inches in diameter, 5–7-lobed, coarsely acutely toothed and cut: petioles 5–8 inches long; stem leaves short-petioled, 3–5-lobed, cut like the radical ones, all rather thick and bright green: inflorescence corymbose, the branches rather spreading: flowers 2 inches long, deep azure blue; spur broad, obtuse, inflated, decurved, little over half as long as sepal; upper petals almost black, 2-lobed, lateral ones greenish: follicles 3 to 5, hairy, July to September. Himalayas. Bot. Mag. 6189. Gartenflora, 1105. Garden **18**: 261. Rev. Hort. 1893, p. 259.

Var. **Walkeri** Hook. Bot. Mag. *t. 6830.* 1885.

Stem very short, leafy, many-flowered: upper leaves less lobed or almost entire, small, long-petioled: flowers very large, light blue with yellow petals. Suited to rockwork.

23. **D. altissimum** Wallich. Pl. Asiat. Rar. **2**: 25. *t. 128.* 1831.

Stem tall and slender, branched; plant shaggy-hairy above: leaves palmately 5-parted, the divisions 3-lobed and toothed; bracts long-lanceolate: flowers blue or purple in long branching racemes; spur straight or slightly incurved, equalling the sepals; petals 2-lobed: 3 erect follicles; seeds not winged nor scaly. August to September. Himalayas.

24. **D. exaltatum** Aiton, Hort. Kew. 1 ed. **2**: 244. 1789.
D. trydactylum Michx. Fl. **1**: 314. 1803.
D. lilacinum Willd. ex Huth. Bot. Jahrb. **20**: 455. 1885.

Stem stout, 2 to 4 feet high, smoothish: leaves flat, nearly glabrous, deeply cleft into 3 to 7 wedge-shaped lobes, which are often trifid, petioles usually not dilated at the base: flowers medium in size, blue with upper petals yellow, sepals nearly equalling the spur in length; flowers on long, crowded, erect, pyramidal racemes: follicles 3, pubescent or smooth; seed coats irregularly wrinkled. June to August. Borders of woods. Alabama and Carolina to Minnesota.

25. **D. Treleasei** B. F. BUSH, n. sp.

Roots fascicled, rather fleshy: stem green, slender but erect, usually 2 to 4 feet high, simple or branched, glabrous throughout, somewhat glaucous: only 1 or 2 true stem leaves, basal leaves 2 to 5, 2 to 5 inches across, about 5-parted, and lobed into narrow segments with calloused tips; petiole of lowest stem leaf dilating: inflorescence open and somewhat branching; pedicels long and very slender, ascending or spreading, pubescent on upper part; spurs and sepals about equal, blue, puberulent without; petals much shorter than sepals and very narrow; upper petals blue at the ends, lower ones blue with dense yellow beard; spur straight, sometimes 2-lobed; sepals narrowly ovate; bractlets very small and slender, usually not very close to the pubescent receptacle: follicles 3, not divergent, sparsely hairy; styles divergent, 1/3 the length of follicles; stigmas 2-lobed; seed coats dark brown, loose and much wrinkled. Collected by B. F. Bush (No. 73), May 28, 1898, Eagle Rock, Mo.; (No. 81) June 10, 1899, Forsyth, Mo. Common in barrens (†).

This is perhaps most nearly related to *D. Carolinianum*. Besides the difference in floral characters the plant is glabrous, somewhat glaucous: roots fleshy, fascicled: racemes open: stem leaves about 2: follicles always 3.

26. **D. Carolinianum** WALT. Fl. Carol. 155. 1788.
D. azureum MICHX. Fl. **1**: 314. 1803.
D. virescens NUTT. Gen. **2**: 14. 1818.
D. azureum var. *laxiflorum* HUTH, Bot. Jahrb. **20**: 450. 1895.

Stem 1 1/2 to 2 1/2 feet high, not much branched, plant somewhat pubescent: leaves 3–5-parted, the divisions 3–5-cleft into usually linear lobes: spicate racemes slender, usually many-flowered: flowers small, azure-blue; spurs slender: 3 to 5 follicles, oblong, erect; seeds transversely wrinkled and roughened. Florida to South Carolina, west to Missouri, Arkansas, and Mississippi. Paxt. Mag. **16**: 258.

Var. **album** HORT.

A garden variety, somewhat taller: leaves larger and with broader divisions: flowers creamy-white. There is a double form of this not much used in the trade.

Var. **vimineum** GRAY, Bot. Gaz. **12**: 52. 1887.

D. vimineum D. DON, in Sweet's Brit. Fl. Gard. II, **4**: *t. 374.* 1838.

D. virescens GRAY, Pl. Lindh. **2**: 142. 1850.

Very slender and tall, more branched, and with looser inflorescence than the type: seeds larger, transversely winged or deeply and thinly wrinkled. Gulf region of Louisiana and Texas. Bot. Mag. 3593. Bot. Reg. **13**: 1999 (as *D. azureum*) (†).

27. **D. Oreganum** HOWELL, Fl. N. W. Am. **1**: 22. 1897.

Tuber flattish, somewhat branched: plant finely pubescent, stem often slender, 1 to 2 feet high, sparingly leafy: leaves dissected into acute linear lobes: racemes rather open: flowers large, blue; sepals broadly lanceolate, shorter than the slender spur, and longer than the petals; upper petals yellow or white at tip, lower ones blue, truncate, bearded: follicles 3 to 4 lines long, 1 line broad, densely tomentose, not spreading; seed triangular with rounded and rugose back, and truncate summit. Open places. Willamette valley, Oregon. It differs from *D. Carolinianum* chiefly in its open paniculate inflorescence, its very small follicles, few stem leaves, and its seed characters (†).

28. **D. Geyeri** GREENE, Erythea, **2**: 189. Dec., 1894.

This differs from *D. camporum* in the color of the flowers, which are almost wholly blue, and in having the upper branchlets much larger than in that species: seeds somewhat winged and roughened. High plains, western Nebraska and Kansas, west to the mountains (†).

Var. **Wootoni** n. var.

D. Wootoni RYDB. Bull. Torr. Club, **26**: 587. 1899.

This southern variety is intermediate between *D. camporum* and *D. Geyeri* in the size of its upper branchlets: sepals blue or bluish, petals white or nearly so. Arizona and New Mexico (†).

Var. **geraniifolium** n. var.

D. geraniifolium RYDB. Bull. Torr. Club, **26**: 583. 1899. Differs from the type only in having broader leaf segments, bractlets variable in size, and pedicels slightly more spreading. Charles valley, Arizona (†).

29. **D. camporum** GREENE, Erythea, **2**: 183. Nov., 1894.
D. albescens RYDB. Bull. Torr. Club, **26**: 583. 1899.

Roots fascicled, fleshy-fibrous: stem stout, erect, 1 to 3 feet high, pubescent throughout, especially above: a dense cluster of finely dissected root-leaves, and very few stem-leaves: raceme long and simple, often dense; pedicels short, erect or appressed: flowers white with blue spots on sepals, and sometimes tinged with blue or flesh color; spurs straight or curved, longer than the sepals; upper petals often tinged with yellow, lower ones 2-lobed, bearded: follicles pubescent, seeds scaly and often winged at the angles. Widely distributed. Manitoba to Arkansas and San Antonio, Texas, west to the Rockies (†).

Var. **Penardi** n. var.

D. Penardi HUTH, in Helios **10**: 27. 1893.

Flowers and leaves much like the type: upper petals toothed: seeds large, black, slightly scaly. Flagstaff Hill and Boulder, Colo., *fide* Huth. No type of this is known in America, but seeds of it have been sent to Columbia University by M. E. Autran, of the Boissier Herbarium. A specimen from Esmeralda Co., Neb. (W. H. Shockley, 1881), in Gray Herbarium agrees in characters of seeds and leaves, but not in color of flowers. It is an intermediate form between this variety and *D. Geyeri* (†).

Var. **macroseratilis** n. var.

D. macroseratilis RYDB. Bull. Torr. Club, **26**: 585. 1899. Slender, leaf-segments fewer than in the type: flowers much the same. Represents the southern variation of the *camporum* group. Tom Greene Co., Tex. (†).

30. **D. scaposum** GREENE, Bot. Gaz. **6**: 156. 1881.

Root a cluster of thickened, fleshy fibres: stem leafless as in *D. nudicaule*; radical leaves rather fleshy, pubescent, 3-parted, the divisions wedge-shaped, 3–5-cleft or toothed, the teeth ending in a calloused point: racemes many-flowered, pedicels as long as the deep azure blue flowers; spur incurved: follicles 3 to 5; seed coat somewhat loose and wrinkled. Southern Utah and Arizona (†).

31. **D. uliginosum** CURRAN, Bull. Calif. Acad. **1**: 151. 1885.

Stem leafless, often branching: radical leaves 3-cleft, lobes entire or 1–3-toothed: racemes rather few-flowered: blue sepals ½ inch long, equalling the straight spur: follicles 3 to 5, erect, nearly ½ inch long; seed coats minutely wrinkled and muriculate. Lake Co., Calif., in swampy ground (†).

32. **D. trolliifolium** GRAY, Proc. Am. Acad. **8**: 375. 1872.
D exaltatum var. *trolliifolium* HUTH, Delph. N. Am. 11. 1892.

Stem 2 to 5 feet, leafy, often reclining: leaves thinnish, large, often reniform at base, 3–7-parted, lobes wedge-shape, incised: racemes in large plants 1 to 2 feet long and very loose: flowers blue with upper petals white; spur and sepals each ¾ inch long: follicles glabrous; seeds with thin wing or crown at the end. April. Moist grounds, Columbia river.

33. **D. elatum** LINN. Sp. Pl. 531. 1753.
D. intermedium WILLD. ex Ait. Hort. Kew. 1 ed. **2**: 243. 1789.
D. Clusianum HOST. Fl. Aust. **2**: 67. 1797.
D. alpinum WALDST. & KIT. Pl. Rar. Hung. **3**: 273. 1812.
D. palmatifidum DC. Syst. **1**: 358. 1818 in part.
D. ranunculifolium WALL. Cat. n. 4716. 1828.
D. pyramidale ROYLE, Ill. Bot. Himal. 56. 1839.
D. discolor FISCH. ex Huth, Bot. Jahrb. **20**: 399. 1895.

Glabrous, 2 to 3½ feet high: leaves somewhat pubescent, 5–7-parted, parts rather narrow, cut-lobed; upper leaves 3–5-parted; petioles not dilated at the base: raceme much like *D. exaltatum*, or more spike-like: flowers blue with dark violet petals; sepals ovate, glabrous, nearly equalling the spurs: follicles 3, seeds transversely wrinkled, not scaly. June to August. Bot. Reg. **23**: 1963. Gartenflora, 736 *b* & *c* (vars.), Flor. des Serr. **12**: 1287 (var. *flore-pleno*). Revue Hort. 1859, p. 529; 1893, p. 258.—A polymorphous and complex species of Europe. It is probable that all or nearly all the plants sold here under this name should be called *D. exaltatum*, which is a closely allied species.

34. **D. grandiflorum** LINN. Sp. Pl. 531. 1753.
D. sinense FISCH. ex Link, Enum. Hort. Berol. **2**: 80. 1822.
D. virgatum JACQ. f. ex Spreng. Syst. **2**: 617. 1825. Not Poir.

Stem rather slender, 2 to 3 feet high: leaves rather small, many times parted into nearly distinct, narrow, linear lobes: flowers large, blue, varying to white, the spur and lower petals often violet, upper petals often yellow; spurs long and taper-pointed: follicles 3, pubescent; seeds triangular, coats wrinkled, not scaly. July to August. Siberia. Bot. Mag. 1686. Garden **46**: *t. 991* & p. 484.

There are several garden varieties: var. *album*, HORT. Flowers pure white. Var. *album-pleno* HORT. Flowers double and pure white. Var. *flore-pleno* HORT. Flowers double, blue, very pretty.

Var. **Chinensis** FISCHER ex DC. Prod. **1**: 53. 1824.

Stems very slender, not much branched: leaves and flowers like the type, but flowers more numerous. China. Lodd. Bot. Cab. **1**: 71. A favorite garden plant.

35. **D. cheilanthum** FISCH. ex DC. Syst. **1**: 352. 1818.
D. magnificum PAXT. Mag. Bot. **16**: 258. 1849.
D. formosum HORT. Not Boiss. & Huet.

Stem erect, simple or branched, 2 to 3 feet high: leaves glabrous or slightly pubescent, 5-parted, the lobes pointed, sub-trifid and somewhat toothed: flowers dark blue, the upper petals sometimes pale yellow, the lower ones inflexed, ovate, entire; spur rather long, straight or somewhat curved: 3 follicles, either glabrous or pubescent; seeds three-cornered, three-winged, not scaly. June and July. Siberia. Bot. Reg. **6**: 473. Gartenflora, **13**: 253.

36. **D. scopulorum** GRAY, Pl. Wright. **2**: 9. 1853.
D. exaltatum HOOK. Fl. **1**: 25. 1829.
D. exaltatum var. *scopulorum* HUTH, Delph. N. Am. 12. 1892.

Stem 2 to 5 feet high, glabrous below: leaves 5–7-parted, the basal ones with very broad segments, which are round and apiculate at apex; other leaves more narrowly cleft; petioles dilating at the base: flowers blue or purple, rarely white, upper petals often yellow; spur one-half inch long, equalling the sepals; racemes simple, densely many-flowered: follicles 3, pubescent; seeds black with loose coats, not scaly, but slightly winged. Aug. to Sept. Moist ground, west of Rockies.

Var. **subalpinum** GRAY, Bot. Gaz. **12**: 52. 1887.

D. occidentale WATS. Bot. Calif. **2**: 428. 1880.

D. elatum var. *occidentale* WATS. Bot. King Exp. 11. 1871.

D. exaltatum var. *Barbeyi* HUTH, Delph. N. Am. 11. 1892.

D. Barbeyi HUTH, Bull. Herb. Boiss. **1**: 335. *t. 17.* 1893.

A smaller plant, pubescent above: broader divisions of leaves: shorter racemes: larger and deeper colored flowers: follicles glabrous; seeds much like the type. Wasatch Mountains.

Var. **stachydeum** GRAY, Bot. Gaz. **12**: 52. 1887.

Stem erect, 3 to 6 feet high: leaves with narrow divisions: plant cinereous-pubescent throughout; seeds black like the type. Oregon to New Mexico and Arizona (†).

Var. **attenuatum** JONES, Proc. Cal. Acad. II, **5**: 617. 1895.

Stems in tufts, 3 to 4 feet high: leaves like the type; pubescence like var. *subalpinum:* flowers large, deep blue, with an odor of musk; sepals long and narrow, 3 times as long as the petals, and longer than the spur; upper petals white, lower ones bearded. Utah. Allied to *D. elatum* (†).

Var. **diversifolium** n. var.

D. diversifolium GREENE, Pitt. **3**: 93. 1896.

Stems often tufted, rather tall and slender: lowest leaves nearly reniform in outline, not more than 3-parted, the parts with lobes rounded at the ends, the sinuses very narrow; other leaves like the type: plant somewhat pubescent in upper parts and on the follicles. Moist meadows, head waters of the Humboldt river, eastern Nevada (†).

37. **D. glaucum** WATS. Bot. Calif. **2**: 427. 1880.

D. scopulorum WATS. Bot. Calif. **1**: 11. 1876.

D. scopulorum var. *glaucum* GRAY, Bot. Gaz. **12**: 52. 1887.

D. exaltatum var. *glaucum* HUTH, Delph. N. Am. 11. 1892.

Much like *D. scopulorum:* plants with a broader type of leaves, often glaucous, glabrous, or the pedicels slightly glandular-pubescent: lower petals deeply lobed: pistils and fruits glabrous; seeds black with light wings. Sierra Nevada, California and San Bernardino mountains, altitude 6,000 to 10,000 feet, north to Alaska (†).

38. **D. glaucescens** RYDB. Mem. N. Y. Bot. Gard. **1**: 155. 1900.

Rootstock thickened: stem somewhat angled, plant finely pubescent especially above, or in age glabrate, somewhat glaucous, 1 to 2 feet high: leaves divided to near the base into 5 to 8 cuneate divisions, these generally deeply 3-cleft: raceme simple, rather short, lower bracts linear, longer than the flowers, the upper ones subulate; pedicels and flowers densely pilose, pedicels spreading: flowers dark blue or variegated with white, somewhat nodding; spur straight, equalling the sepals; upper petals yellowish white, tipped and tinged with blue: ovaries densely hairy; fruit not seen. Rocky places, Cedar mountains, Montana, and Yellowstone Park. Differs from *D. glaucum* in its shorter and more pilose inflorescence, lower and more tufted habit, and in hairy ovaries (†).

Var. **multicaule** RYDB. Mem. N. Y. Bot. Gard. **1**: 156. 1900.

More bushy than the type and less pubescent: leaf segments longer and narrower: flowers smaller; spur curved. Rock slides, Cedar Mt., Montana (†).

39. **D. Nuttallii** GRAY, Bot. Gaz. **12**: 54. 1887.

D. exaltatum var. *Nuttallii* HUTH, Delph. N. Am. 9. 1892.

D. Columbianum GREENE, Erythea, **2**: 193. 1894.

D. simplex NUTT. ex Huth, Bot. Jahrb. **20**: 472. 1895.

Stem erect, simple, nearly glabrous, leafy, 1½ to 2½ feet high: leaves thinnish, 3–5-parted, parts divided into many linear-oblong lobes: racemes long, many-flowered; sepals deep blue, ovate, sparingly pubescent, shorter than the spur; petals blue or upper ones yellow, lower ones white-bearded: follicles 3, pubescent, rather erect; seeds thin, dark with yellow wings. Summer. Low open woods, Columbia River.

Var. **leucophæum** n. var.

D. leucophæum GREENE, Erythea, **3**: 118. 1895.

A slender whitish plant, with sepals and lower petals white, upper petals blue. Oregon (†).

40. **D. distichum** GEYER, in Hook. London Journ. Bot. 6: 68. 1847.
D. simplex var. *distichiflorum* HOOK. l. c. 67.
D. azureum TORR. Bot. Wilkes Exped. 217. 1854.

Not so tall as *D. simplex*, glabrous or inflorescence puberulent: leaves rather thicker: flowers and fruit much like those of *D. simplex;* upper petals whitish. Low prairies of eastern Oregon and Washington, eastward in Montana (†).

Without seeing the follicle and seeds of *D. Burkei* GREENE, Erythea, **2**: 183, 1894, it is best not to consider it as distinct from *D. distichum*. The type specimen is at Kew. Thus far no preserved specimens showing follicles and seeds were found. The type is supposed to have come from the "Snake Country, probably in Idaho," but collectors in that region have been unable to rediscover the plant.

41. **D. simplex** DOUGL. ex Hook. Fl. **1**: 25. 1829.
D. azureum var. *simplex* HUTH, Delph. N. Am. 9. 1892.

Stem nearly simple, 2 to 3 feet high, soft-pubescent throughout: leaves many-parted into linear divisions and lobes: racemes dense, little branched: flowers pale blue with upper petals yellow, lower petals white-bearded; sepals equalling the spur: follicles 3, pubescent; seeds dark with margins white-winged. June. Mountains of Idaho and Oregon.

42. **D. formosum** BOISS. & HUET, Diagn. Sec. II, **5**: 13. 1856.
D. speciosum BOISS. & HUET ex Huth, Bot. Jahrb. **20**: 410. 1885. Not. M. Bieb.

Stem strong, 2 to 3 feet high, hairy below, rather glabrous above: lower leaves 5–7-parted, long-petioled, upper ones 3–5-parted, short-petioled or sessile, all alternate: racemes many-flowered: flowers blue with indigo margins; spur long, violet colored, bifid at the tips: follicles 3, pubescent; seeds scaly. June to July. Asia Minor, perhaps; but its origin is disputed. Flor. des Serr. **12**: 1185.

43. **D. Maackianum** REGEL, in Mem. Acad. Petersb. VII, **4**: 9. 1861.

Erect, 3 feet high, pubescent or glabrous, branched above: leaves pubescent on both sides, base often truncate or reniform, 3–5-parted, the parts serrate; the bases of petioles dilated:

flowers in loose panicles; peduncles yellow-hairy, with the bracts often inserted above the base; sepals blue, ½ as long as the spurs; petals dark violet: follicles often glabrous, ¾ inch long; seeds small, distinctly scaly. July. Siberia. Gartenflora, 344.

44. **D. hybridum** STEPH. ex Willd. Sp. Pl. **2**: 1229. 1799.
D. davuricum GEORGI, Beschr. Russ. Reich. III, **4**: 1052. 1800.
D. fissum WALDST. & KIT. Pl. Rar. Hung. **1**: 83. *t. 81*. 1802.
D. hirsutum PERS. Syn. **2**: 82. 1807.
D. tauricum PALLAS ex Bieb. Fl. Taur. Cauc. **2**: 13. 1808.

Stem 3 to 4 feet high, pubescent above: root somewhat bulbous: leaves 5- to many-parted, lobes linear, petioles dilated and sheathing at the base: racemes dense: flowers blue, lower limbs white-bearded; straight spur, longer than the sepals: follicles 3, hairy; ovate seeds with transverse scales. June to August. Mountains of Asia. Revue Hort. 1893, p. 258.—There are many double and semi-double varieties of this type. Var. *flore-pleno* HORT., has large double flowers colored as in the type. Var. *Barlowi* PAXT., has very large semi-double flowers, deep blue with brownish center; a supposed hybrid with *D. grandiflorum*. Bot. Reg. 1944.

45. **D. Madrense** WATS. Proc. Am. Acad. **25**: 141. 1890.

Resembles *D. pauciflorum;* slender, 2 feet high or less, from a thickened rootstock, pubescent with reflexed hairs below, glandular-hispid above: leaves 3-parted, the lobes 5–7-cleft into linear-oblong segments, lowest ones less cleft: flowers few, small, pale blue, in a slender raceme; spur narrow, straight; lateral petals long-villous: carpels short, glandular-hispid. May. In mountains near Monterey, Mexico. Collected by Pringle (n. 3014) (†).

46. **D. bicornutum** HEMSL. Diagn. Pl. Nov. **2**: 17. 1879.

Stem nearly simple, stout, 2 to 4 feet high, glabrous or puberulent on inflorescence and under the leaves: leaves long-petioled, 5-parted, 3–5-lobed; bracts linear; pedicels bibracteolate; bractlets cuneate: flowers blue, spurs nearly straight, sepals oblong; upper petals narrow, obtuse or retuse; lower petals bifid: carpels 3, puberulent at first. Oaxaca (†).

Var. **Hemsleyi** HUTH, Bot. Jahrb. **20**: 453. 1895.

Spurs distinctly 2-lobed at the end (†).

47. **D. Ehrenbergi** HUTH, in Bull. Herb. Boiss. **1**: 336. *t. 17, f. 2.* 1893.

Stem simple, succulent, very leafy, 1 to 2 feet high; petioles long with dilating bases: leaves 3–5-parted, cut into many oblong or linear lobes: racemes few-flowered, pedicels erect, lower ones 1 to 2 inches long: flowers blue; spurs straight, equalling the sepals, which are oval, pubescent; upper petals yellow with blue tips, lower ones 2-lobed, sparsely bearded, appendiculate at base: follicles 3, erect, pubescent. Near El Cerro, Mex. (†).

48. **D. pedatisectum** HEMSL. Diagn. Pl. Nov. **2**: 18. 1879.

Stem branching, branches smooth: leaves 3–7-parted, parts scarcely lobed, puberulent: flowers blue, on long, slender, puberulent pedicels; bracts and bractlets linear-subulate; sepals oblique-oblong; upper petals deeply 2-lobed, much shorter than the spur, lower petals 2-lobed, bearded, appendiculate at base; stigmas glabrous: follicles 3, tomentose when young; styles long. Mexico. Specimen at Kew (†).

49. **D. latisepalum** HEMSL. Diagn. Pl. Nov. **2**: 17. 1879.

Plant pubescent or villose: stem nearly simple: leaves 5-parted; the parts of the basal leaves again 3–5-lobed, parts of stem leaves nearly linear: flowers few on slender pedicels; spurs slightly curved, nearly equalling the sepals; sepals villose; upper petals narrow, slightly 2-lobed at the points; lower petals not appendiculate, deeply 2-lobed, much bearded on both sides; stamens glabrous: follicles 3, clothed with white pubescence when young. 9,000 feet. Mt. Tanga, Oaxaca, Mex. Specimen at Kew (†).

50. **D. tenuisectum** GREENE, Erythea, **2**: 184. 1894.

Root thick, woody, deep: stem 2 to 3 feet high, simple or little branched, not very stout, sulcate above: plant finely pubescent throughout, leafy: leaves very finely dissected into linear segments, the lower stem leaves on rather long petioles dilated at base: racemes about 8 inches long, loosely flowered, pedicels very slender, nearly erect, upper ones not longer than the spurs; bractlets of lower pedicels lobed; bractlets of upper pedicels slender and near the flowers; sepals about equal to spur in length, blue within, tinged with yellow outside; upper petals yellow with blue tips; lower ones either blue or yellowish, 2-lobed with a few long, white hairs on inside of lobes: follicles 3, large, slightly spreading; seeds nearly black, coats roughened, forming slight wings at the angles. Cool banks of ravines in plains at base of the Sierra Madre, Chihuahua, Mex. Collected first by C. G. Pringle (n. 1184), Sept. 27, 1887. Differs essentially from *D. scopulorum* in its finely dissected leaves (†).

51. **D. leptophyllum** HEMSL. Diagn. Pl. Nov. **2**: 18. 1879.

Stem 3 to 4 feet high, glabrous, somewhat branched: leaves glabrous, deeply 5-parted, and cut into oblong to linear lobes; bracts entire, linear: inflorescence open, few-flowered; pedicels 1 to 2 inches long; bractlets remote from flower: flowers large, blue; spur large; sepals puberulent, ovate, obtuse, ⅔ inch long; petals dull yellow; upper ones slightly 2-lobed, nearly glabrous; lower ones deeply 2-lobed, slightly bearded: follicles 3, densely villose when young, half inch long when mature, not spreading: seed slightly winged, and transversely wrinkled. October. San Luis Potosi and Montes San Miguelito, Guanajuata, southern Mexico (†).

52. **D. Wislizeni** ENGELM. in Wisliz. Tour N. Mex. 106. 1848.

Stem simple, 2 to 2½ feet high, slender, glabrous, glaucous; petioles elongated, lower ones dilated at base: leaves cut into linear segments; pedicels long: flowers few, spur 2½ inches long, blue, slightly pubescent outside; the outer sepal acute, others obtuse: follicles glabrous even when young. Wislizeni region, Mexico. Later found near Cosihuiriachi, 8,000 feet. In flower in Sept. (†).

EXCLUDED.

D. urceolatum JACQ. Coll. **1**: 153, 1786, is figured in Bot. Mag. n. 1791, but no nativity is given. From character it may be allied to *D. exaltatum*, but it is probably not American.

INDEX TO SPECIFIC AND VARIETAL NAMES OF DELPHINIUM.

XXVI. NATIVE AND CULTIVATED RANUNCULI OF NORTH AMERICA AND SEGREGATED GENERA.

K. C. Davis.

Few groups of plants are perhaps less understood than this one. The range of variation in characters is rather limited and yet the number of species is very great. Six genera have taken from *Ranunculus* about thirty-six species and yet that genus retains more species than any other of the order Ranunculaceae. About 350 names have already been given to American plants of this group.

Key to Genera.

A. Akenes transversely wrinkled; roots fibrous; aquatic or ditch herbs; flowers white...**Batrachium.**

AA. Akenes not transversely wrinkled.

B. Developed carpels not longitudinally ribbed or striated.

C. Roots not a cluster of thickened tubers, or several times longer than thick.

D. Flowers mostly yellow or white; akenes compressed, never lanceolate, smooth, papillose or spiny............**Ranunculus.**

DD. Flowers white; akenes lanceolate, utricular; style hooked. **Kumlienia.**

CC. Roots a cluster of thickened tubers; leaves crenate, cordate; cotyledon only 1..**Ficaria.**

BB. Developed carpels longitudinally ribbed or striated.

C. Leaves pinnately compound or lobed; akenes terete, style persistent, slender, recurved.........................**Cyrtorhyncha.**

CC. Leaves not as above; akenes compressed.

D. Akenes with beaks somewhat reflexed; leaves rounded and lobed..**Arcteranthis.**

DD. Akenes minutely sharp-pointed; leaves crenate-dentate, oval-cordate to reniform................................**Oxygraphis.**

BATRACHIUM S. F. GRAY, Nat. Arr. Brit. Pl. **2**: 720. 1821.

(Name from the Greek, in allusion to the aquatic habitat of the plants.)

Aquatic, or semi-aquatic perennial herbs; leaves dissected or lobed, submerged ones usually with filiform segments; petioles with stipular-dilated membranous bases: flowers solitary, opposite the leaves, rather small, white; sepals usually 5; petals usually 5, base often yellowish; claw with a naked nectar pit; stamens several or many: ovules oblique, compressed, not margined, nearly beakless, transversely rugose. About 20 species, mostly of north temperate regions of the world. The following are all that are found in North America. Section BATRACHIUM DC. Syst. **1**: 233, under *Ranunculus*.

KEY TO SPECIES.

A. Aquatic leaves with filiform segments present; receptacle hairy.
  B. Leaves all sessile or nearly so......................1. *divaricatum*.
  BB. Leaves, except the upper ones long-petioled.
    C. Emersed leaves always present, with segments broader than linear..2. *aquatile*.
    CC. Emersed leaves if present only fleshy or nearly linear.
3. *trichophyllum*.
AA. Aquatic leaves none, or few, and with few divisions; receptacle glabrous.
  B. Styles minute, shorter than the ovaries............4. *hederaceum*.
  BB. Styles long and filiform...................................5. *Lobbii*.

1. **B. divaricatum** WIMM. Fl. Schles. 10. 1841.
Ranunculus aquatilis β. LINN. Sp. Pl. 556. 1753.
R. divaricatus SCHRANK, Baier. Fl. **2**: 104. 1789.
R. circinatus SIBTH. Fl. Oxon. 175. 1794.
R. aquatilus var. *stagnatalis* DC. Prod. **1**: 27. 1824.
Batrachium circinatum SPACH. Hist. Veg. **7**: 201. 1839.
R. stagnatalis WALLR. Sched. Crit. 285. 1848.
R. aquatilis var. *divaricatus* GRAY, Man. 2 ed. 7. 1856.
R. longirostris GODRON, Ess. 32. *f. 9*. 1862.
R. aquatilis var. *longirostris* LAWSON, Rev. Canad. Ranunc. 43. 1870.

Leaves sessile to the dilated stipule-like base, dissected into rigid lobes spreading at right angles to the stem, not collapsing when taken from the water; no floating nor emersed leaves:

petals several-nerved, deciduous: styles subulate, as long as the ovaries, stigma surface along the inner side: receptacle hairy. July. Chihuahua, Mex., Texas to British Columbia, eastward and northward to Hudson Bay. Also in Europe.

2. **B. aquatile** WIMM. Fl. Schles. 8. 1841.
Ranunculus aquatilis LINN. Sp. Pl. 556. 1753.
R. aquatilis var. *heterophyllus* DC. Prod. **1**: 26. 1824.
R. aquatilis var. *hispidulus* DREW, Bull. Torr. Club, **16**: 150. 1889.
R. Grayanus FREYN, Deutsche Bot. Monats. **8**: 179. 1891.

Floating leaves round-reniform, 3–5-lobed or parted, and the divisions 2–3-cleft; submersed ones with filiform segments, widely spreading, rather firm, but collapsing when taken from water; all the leaves often slightly hispid below: styles subulate, shorter than the ovaries, introrsely stigmatose: receptacle hairy among the carpels. Ponds and quiet shallow streams. California to Alaska, Europe and Asia.

3. **B. trichophyllum** BOSSCH. Prod. Fl. Bot. 5. 1850.
Ranunculus trichophyllus CHAIX. in Vill. Hist. Pl. Dauph. **1**: 335. 1786.
R. flaccidus PERS. in Usteri. Ann. Bot. **5**: pt. 14: 39. 1795.
R. pantothrix BROT. ex DC. Syst. **1**: 235. 1818.
R. aquatilis var. *cæspitosus* DC. Prod. **1**: 26. 1824.
R. aquatilis var. *brachypus* HOOK. & ARN. Bot. Beech. 316. 1841.
R. confervoides FRIES, Sum. Veg. Scand. **1**: 139. 1846.
R. aquatilis var. *submersus* GORDON, in Gren. & Godr. Fl. Fr. **1**: 23. 1848.
R. aquatilis var. *trichophyllus* GRAY, Man. 5 ed. 40. 1867.
R. Porteri BRITTON, Bull. Torr. Club, **17**: 310. 1890.
R. aquatilis var. *confervoides* GRAY, Syn. Fl. **1**: 21. 1895.
R. aquatilis var. *flaccidus* GRAY, l. c. 21.

This species is polymorphous, including those with filiform segments to all the leaves or with some of the leaves rather fleshy, or some narrowly linear, and the submersed leaves are mostly flaccid, but may be rigid when taken from the water. The plants have adapted themselves to either aquatic or to muddy habitats. Widely distributed; America, Europe, Asia.

4. **B. hederaceum** S. F. Gray, Nat. Arr. Brit. Pl. **2**: 721. 1821.

Ranunculus hederaceus Linn. Sp. Pl. 556. 1753.

Semi-aquatic, rooting freely from the nodes, in the mud: leaves seldom submersed, but floating or resting on the mud; all reniform or nearly so, angulate-lobed, never finely dissected; peduncles as short as the petioles: petals deciduous: styles shorter than ovaries, introrsely stigmatose; receptacle glabrous. Naturalized from Europe at Norfolk, Va., and on Newfoundland.

5. **B. Lobbii** Howell, Fl. N. W. Am. **1**: 13. 1897.

Ranunculus hederaceus var. Torr. Pac. Ry. Rep. **4**: 62. 1853.

R. hederaceus var. *Lobbii* Lawson, Rev. Canad. Ranunc. 44. 1870.

R. hydrocharis subsp. *Lobbii* Hiern. Seem. Journ. Bot. **9**: 66. *t. 114*. 1871.

R. aquatilis var. *Lobbii* Wats. Bibl. Index 17. 1878.

R. Lobbii Gray, Proc. Am. Acad. **21**: 364. 1886.

Leaves commonly all floating, small, truncate or cordate at base, divergently 3-parted: petals persistent; stamens 5 to 10; styles long and filiform; stigma terminal. In mud or water of pools, etc. California and Oregon.

RANUNCULUS Linn. Sp. Pl. 548. 1753.

The name is the Latin diminutive for frog, given because many of the species grow in wet places.

The genus is by far the largest in the Ranunculaceæ, comprising upwards of 200 species. 90 of these are natives or naturalized in North America; of those in the trade in this country five are native here; one in the Canaries; five in Europe, and two of these also in Asia. Those cultivated are so indicated in the following treatment. Members of the genus are found in mountainous regions, and in cold and temperate parts of the globe.

Perennial (rarely annual) herbs: leaves alternate, simple, entire, lobed, dissected or divided: flowers yellow, white or rose; sepals usually 5, deciduous or marcescent-persistent; petals 5 or more, conspicuous or minute, nectar pit and scale at base; carpels many, 1-ovuled: akenes generally flattened, smooth, papillose or spiny, borne in a head or spike; styles minute or elongated.

In 1886 A. Gray wrote a revision of the North American *Ranunculi* found north of northern Mexico. This was published in Proc. Am. Acad. **21**: 363–378. In Syn. Flora **1**: 20–39, the revision is brought down to 1895. Since that date the list of species has rapidly increased and since Gray's first revision two new North American genera have been segregated from this one. In 1892 N. L. Britton discussed six species "R. repens and its Eastern North American allies," Trans. N. Y. Acad. Sci. **12**: 2–6. Britton and Brown's Ill. Flora gives 31 species in eastern United States and Canada. In 1880 J. Freyn gave a long treatment of about ten species in Flora, **63**: 179.

The present treatment includes 96 species, eighteen of which are found only in Mexico and south of there.

TENTATIVE KEY TO SPECIES AND GROUPS OF SPECIES.

A. Sepals and petals deciduous (except in 77); petals yellow or white, with nectary on the claw covered by scale; sepals 5, (rarely only 3 or 4); petals 5 or more; carpels not utricular when mature, usually somewhat compressed.—Sec. EURANUNCULUS, Gray.
  B. Leaves, at least some of them, lobed or divided.
    C. Flowers yellow (except some cultivated forms of 31).
      D. Plants terrestrial.
        E. Plants not spreading by rooting branches or stolons, except in 12, 26 and 27.
          F. Sepals glabrous or pubescent but not densely clothed with black or brown wool.
            G. Akenes armed or clothed with prickles, spines or prominent papillæ.........1. *arvensis;* 2. *muricatus;* 3. *parviflorus;* 4. *hebecarpus;* 5. *Galeottii.*
            GG. Akenes nearly smooth or pubescent.
              H. Leaves, at least some of the radical ones, divided, the leaflets either sessile or stalked.
                I. Radical leaves with some of the leaflets stalked.
                  J. Petals short, about the length of the sepals, or shorter.
                    K. Head of fruit globose..............6. *alceus.*
                    KK. Head of fruit oblong to cylindric. 7. *Pennsylvanicus.*
                  JJ. Petals longer than the sepals.

K. Beaks of akenes not hooked.
L. Petals about 5 (or 6), except perhaps in 13.
M. Head of fruit longer than thick.
N. Sepals reflexed.
8. *Macounii;* 9. *Sardous.*
NN. Sepals spreading 10. *micranthus;* 11. *fascicularis;* 12. *septentrionalis.*
MM. Head of fruit globose.
N. Stem leaves present; roots fibrous.
13. *Hookeri;* 14. *pilosus;* 15. *Bloomeri;* 16. *hispidus.*
NN. Stem leaves present, roots from a thickened bulb......17. *bulbosus.*
NNN. Stem leaves wanting.
18. *Icelandicus.*
LL. Petals 7 to 16 (double in 21).
19. *orthorhynchus;* 20. *dichotomus;* 21. *Llavænus;* 22. *macranthus:* 23. *subalpinus.*
KK. Beaks of akenes recurved or hooked.
24. *canus;* 25. *amarillo;* 26. *repens.*
II. Radical leaves with the leaflets all sessile.
27. *palmatus;* 28. *Aschenbornianus;* 29. *acriformis;* 30. *Californicus;* 31. *Asiaticus.*
HH. Leaves, at least the radical ones, usually not parted to the base, and in some species only lobed or cleft.
I. Types found native or naturalized north of Mexico.
J. Sepals exceeding the petals, or sometimes a trifle shorter, recurved.
K. Beaks of akenes minute, curved, or nearly wanting....32. *abortivus;* 33. *sceleratus;* 34. *eremogenes.*
KK. Beaks of akenes nearly half the length of the body, recurved...35. *Allegheniensis;* 36. *recurvatus;* 37. *Bongardi.*
JJ. Sepals decidedly shorter than the petals.
K. Akenes compressed, or flat, with firm or indurated margin.
L. Sepals reflexed...........38. *occidentalis;* 39. *Turneri.*

LL. Sepals spreading.
40. *acris;* 41. *McCallai.*
KK. Akenes turgid or lenticular, marginless.
L. Head of fruit oblong or cylindraceous.
42. *pedatifidus;* 43. *vicinalis;* 44. *Eschscholtzii;* 45 *eximius;* 46. *saxicola.*
LL. Head of fruit globose or oval.
47. *Suksdorfii;* 48. *ovalis;* 49. *Arizonicus.*
II. Types from Old World, cultivated here, not naturalized.........................50. *montanus;* 51. *corthusæfolius.*
III. Types found only in Mexico and southward (see also var. of 32).
J. Plants with several slender scapose stems bearing only bracts and terminal flowers.
52. *longipedunculatus.*
JJ. Plants usually with true stems, 1 to 8 inches high................. ....53. *Donianus;* 54. *multicaulis;* 55. *Mexicanus.*
JJJ. Plants with true stems one foot high or more.............56. *uncinatus;* 57. *petiolaris.*
HHH. Leaves all 2 to 4 times ternately parted or divided, divisions 1 line or less in width; flowers few, large; plants alpine or subalpine, low, decumbent or spreading..........58. *adoneus;* 59. *triternatus.*
HHHH. Leaves all palmately or pedately lobed or divided; sepals nearly equal to the petals; plants low, tufted, arctic or alpine.
60. *Grayi;* 61. *pygmæus.*
HHHHH. Leaves, some of them, quite entire (except in 62); others with a few entire lobes; plants low and glabrous......62. *oxynotus;* 63. *digitatus;* 64. *glaberrimus.*
FF. Sepals densely clothed beneath with black or dark brown wool..................65. *Macauleyi;* 66. *nivalis.*
EE. Plants spreading by slender creeping stolons or rootstocks.......67. *natans;* 68. *hyperboreus;* 69. *Lapponicus.*
DD. Plants aquatic or amphibious.
70. *delphinifolius;* 71. *Purshii;* 72. *Missouriensis.*
CC. Flowers white (except in a double garden form of 73).
73. *aconitifolius;* 74. *Pallasii.*
BB. Leaves entire or only denticulate or crenulate, not lobed, from linear to oblong-lanceolate (or ovate in 75); plants varying from

erect to creeping and rooting at the nodes; aquatic or in low wet ground, or terrestrial..........................Sec. FLAMMULA.

C. Blades of stem leaves amplexicaul, leaves entire; flowers white...75. *amplexicaulis.*

CC. Blades of stem leaves not amplexicaul; flowers yellow.

D. Stamens numerous.

E. Plant low or erect, not spreading by slender creeping stems.

F. Habitat aquatic..........................76. *Lambertianus.*

FF. Habitat terrestrial.

G. Sepals and petals persistent...........77. *arnoglossus.*

GG. Sepals and petals deciduous.

H. Claw of petal 1 line long........78. *unguiculatus.*

HH. Claw of petal not nearly so long.

I. Akenes beaked.

J. Stems 2 to 3 feet high, often rooting at lower nodes...79. *ambigens.*

JJ. Stems much lower, not rooting at nodes.

K. Mature fruit glabrous.

L. Beak as long as the akene body. 80. *Madrensis.*

LL. Beak much shorter than akene body.

M. Petals 4 to 6 lines long; plants solitary, not much tufted..81. *alismæfolius.*

MM. Petals about 3 lines long; plants often tufted or covering the ground. 82. *alismellus.*

KK. Mature fruit villous-pubescent. 83. *Lemmoni.*

II. Akenes beakless; styles deciduous. 84. *oblongifolius.*

EE. Plant spreading by slender, or fistulous creeping stems.

F. Lower leaves sometimes cordate; flower stems ascending.

G. Margins of some of the leaves slightly denticulate. 85. *hydrocharoides.*

GG. Margins of leaves entire............86. *samolifolius.*

FF. Lower leaves never cordate.

G. Petals no longer than the sepals.......87. *stolonifer.*

GG. Petals nearly twice the length of the sepals.

H. Number of petals 8 to 10; plant glabrous. 88. *vagans.*

HH. Number of petals 4 to 8; plants never entirely glabrous.

I. Stems filiform or nearly so, and usually rooting at each node; peduncles usually less than 2 inches; radical leaves few..............89. *reptans.*

II. Stems larger, at least at the base, peduncles longer.

J. Radical leaves not tufted; stems seldom ascending..........................90. *Unalaschensis.*

JJ. Radical leaves tufted; stem somewhat ascending...........................91. *microlonchus.*

DD. Stamens only 1 to ten.

E. Head of fruit oblong; stem leaves distinctly petioled. 92. *trachyspermus.*

EE. Head of fruit small, globose; stem leaves sessile or nearly so...93. *pusillus.*

AA. Sepals and petals marcescent-persistent; petals white or rose, with ample nectary and imperfect scale; carpels wholly or partly utricular, but compressed and broad.......Sec. CRYMODES, Gray.

B. Plant and sepals somewhat pubescent.................94. *glacialis.*

BB. Plant and sepals glabrous.

C. Akenes about 3 lines long, wholly utricular; plant about 6 inches high, stoutish..................................95. *Andersoni.*

CC. Akenes hardly half as large, not inflated; plant taller and more slender...96. *juniperinus.*

1. **R. arvensis** LINN. Sp. Pl. 555. 1753.

Glabrous or sparsely pubescent, erect, 1 to 2 feet high, branched above: lower leaves petioled, others sessile or nearly so, nearly all divided; leaflets either stalked or sessile, cleft or parted into linear-oblong segments: petals yellow, 2 to 3 lines long; sepals of same length, spreading: akenes few, flattened, armed with long spines; beak half their length or more, stout; head depressed-globose. Europe. Naturalized in New Jersey, and near northern seaports.

2. **R. muricatus** LINN. Sp. Pl. 555. 1753.

Sparsely pubescent or glabrous, often erect, succulent, branched near the base, 6 to 20 inches high: lower leaves on long broad petioles, reniform to round cordate, 3–5-cleft and coarsely crenate-dentate: petals deep yellow, 3 lines long; sepals shorter, spreading: akenes compressed, large, conspicuously muricate-spiny; beak stout, slightly curved: head loose, globose. Asia and Europe. Naturalized near towns in Virginia to Louisiana, also in California and southern Oregon.

3. **R. parviflorus** Linn. Sp. Pl. 2 ed. 780. 1763.
R. trachyspermus Ell. Sketch **2**: 65. 1824.

Hairy, 4 to 10 inches high, very slender, spreading, branching: leaves petioled, reniform to cordate-orbicular, ½ to 1 inch broad, 3-cleft or parted or divided, segments cuneate, oval, obtuse, cut and toothed; the upper leaves sometimes 5-parted, short-petioled: peduncles short, slender; petals pale yellow, hardly 1 line long; sepals about the same length: akenes oblique, very flat, margined, papillose; beak short, sharp. Europe. Naturalized in waste places, Maryland, North Carolina, Florida, west to Arkansas and Texas.

4. **R. hebecarpus** Hook. & Arn. Bot. Beech. 316. 1841.
R. parviflorus var. Torr. & Gray, Fl. **1**: 25, 659. 1838.
R. hebecarpus var. *pusillus* Wats. Bot. Calif. **1**: 8. 1876.

Plant shaggy-hairy, slender, ½ to 1 foot high, branched: leaves reniform to roundish, small, 3–5-parted or divided, segments sessile or subsessile, often laciniately cleft: peduncles short; petals hardly a line long, pale yellow; sepals about equalling the petals: akenes few, semi-oval, compressed, clothed with recurved bristles; beak short, subulate, recurved: head small. Washington through western California to lower California.

5. **R. Caleottii** Turcz. in Bull. Soc. Nat. Mosc. **27**: 2: 276. 1854.

Roots not seen: plants otherwise annual: stem somewhat branched, radical and lower stem-leaves 3-parted, the divisions stalked, 3-lobed or parted, the lobes toothed or cut, acute or obtuse, appressed pilose; petioles openly pilose with appressed hairs; upper stem-leaves 3-parted, the highest one sometimes not lobed: sepals reflexed, openly pilose; petals longer than sepals, obovate-oblong, obtuse: akenes compressed, margined, tubercles on the sides, style deciduous. Oaxaca, Mex. Alt. 7,000 to 9,000 feet.

6. **R. alceus** Greene, Erythea, **3**: 69. 1895.

One foot high or less, slender, branching, soft-hirsute and villous: leaves about 1 inch long, and much like those of *R. canus:* petals roundly obovate, about 1 line long, yellow: akenes many, obliquely obovoid, glabrous; beak stout, recurved: head globose. Elk mountains, Mendocino County, Calif.

7. **R. Pennsylvanicus** Linn. f. Suppl. 272. 1781.
R. Canadensis Jacq. Misc. **2**: 343. 1781.
R. trifolius Moench. Meth. Suppl. 70. 1802.
R. hispidus Pursh, Fl. **2**: 395. 1814. Not Michx.
R. fascicularis Wats. Bot. King Exp. 9. 1871.

Plant hirsute or hispid, stout, erect, 8 to 20 inches high, very leafy, but the radical leaves often dying down: leaves petioled, ternately compound; leaflets well stalked, 3-parted and cleft, much incised and toothed, segments acute: flowers small, yellow, on short peduncles; petals oblong to obovate, 1 to 2 lines long; sepals about the same length, reflexed: receptacle hairy: akenes 1 line long, oblique or semi-oval, compressed, roughened; beak subulate, stout, short, nearly straight: head of fruit oblong to cylindric. Wet ground, Nova Scotia to Georgia west to Arizona and British Columbia Jacq. Ic. Rar. *t. 105*.

8. **R. Macounii** Britton, Trans. N. Y. Acad. Sci. **12**: 3. 1892.
R. hispidus Hook. Fl. **1**: 19. 1829. Not Michx.
R. repens var. *hispidus* Torr. & Gray, Fl. **1**: 658. 1838. In part.

Erect or declined, hairy, branching, 1 to 2 feet long, stems rather few leaved: leaves ternately compound, leaflets usually on slender stalks, crenate, variously cleft and lobed, segments acute: petals yellow, obovate, about 3 lines long; sepals shorter, often reflexed, falling early: akenes smooth; beak subulate, flat, short and sharp: head oblong or oval. Moist places. western Ontario to British Columbia south to Iowa, and in mountains to Arizona.

Var. **Oreganus** n. var.
R. hispidus var. *Oreganus* Gray, Proc. Am. Acad. **21**: 376. 1886.
R. Oreganus Howell, Fl. N. W. Am. **1**: 19. 1897.

Plant often taller, smoothish or with scattered hairs: flowers often larger. Shaded wet grounds, Willamette valley, Ore., to Frazer valley, east to Kootenai lake, Brit. Col.

9. **R. Sardous** Crantz, Stirp. Austr. **2**: 84. 1763.
R. parvulus Linn. Mant. **1**: 79. 1767.
R. Philonotis Ehrh. Beitr. **2**: 145. 1788.
R. hirsutus Curt. Fl. Lond. **2**: *t. 40*. 1821.

Plant hirsute especially below, 3 to 15 inches high: lower leaves 3-parted or 3-foliate, middle leaflets stalked, others often sessile, all obovate-cuneate to roundish, cleft and toothed as in *R. repens:* petals yellow, 4 to 6 lines long; sepals much shorter, reflexed: akenes flat, orbicular, thin-margined; beak short-subulate: head oblong. Asia Minor, northern Africa, Europe. Naturalized at Savannah, Norfolk, Philadelphia, New York and St. John, N. B.

10. **R. micranthus** NUTT. ex Torr. & Gray, Fl. **1**: 18. 1838.
R. abortivus var. *micranthus* GRAY, Man. 5 ed. 42. 1867.

Allied to *R. abortivus*, but more slender, villous; roots of slender tubers: most of the lower leaves 3-parted, or divided with the leaflets stalked: receptacle glabrous or nearly so. April to May. Massachusetts, New York to Colorado, and Saskatchewan.

11. **R. fascicularis** MUHL. Cat. 54. 1813.

Roots a fascicle of thickened fibres or tubers: plant finely pubescent throughout, 3 to 10 inches high, tufted: leaves mostly radical, long-petioled, 3- (rarely 5-) divided; middle leaflet stalked, others usually sessile, deeply lobed and cleft into oblong segments: petals 5 to 6, bright yellow, obovate-oblong, rounded at apex, 4 to 6 lines long; sepals much shorter, spreading: akenes flattened, slightly margined, glabrous; beak nearly their length; head ovate or oblong. April to May. Ontario, New England to Texas, and Manitoba. Meehan's Mo. 2. *t. 1.* *R. apricus* GREENE, Pitt. **4**: 145, 1900, is a form from Indian Territory with the leaflets rather narrow and sometimes entire.

Var. **Deforesti** n. var.

Differs from the type in having all leaves but the first radical ones cleft into linear to spatulate lobes: roots less thickened: plant 3 to 4 inches high: petals 5 to 10, linear to oblong, 2 to 4 lines long. Collected by Harry P. DeForest (G. 42) near Rossville, Ill., April, 1885.

12. **R. septentrionalis** POIR. in Lam. Encycl. **6**: 125. 1804.
? *R. lucidus* POIR. l. c. 113.
R. tomentosus POIR. l. c. 127.
? *R. Philonotis* PURSH, Fl. **2**: 393. 1814.
R. Belvisii DC. Syst. **1**: 291. 1818.

R. fascicularis SCHLECHT. Animad. Ranunc. 2: 30. *t. 2.* 1820. Not Muhl.

R. Schlechtendalii HOOK. Fl. 1: 21. 1829. (As to type.)

Plant glabrous or sometimes pubescent, 1 to 3 feet high, branching, lower branches often rooting at their nodes, and running some distance: lower petioles very long: leaves composed of 3-stalked leaflets, which are mostly cuneate and cleft into broad lobes: petals yellow, obovate, 6 lines long; sepals half as long, spreading: akenes much compressed, widely margined; beak nearly as long, subulate, flat: head of fruit rather small, ovoid. Often in low, wet places. New Brunswick to Georgia, northwestward to Winnipeg.

13. **R. Hookeri** SCHLECHT. in Linnæa, 9: 610. 1835.

Stem erect, branched, 1 to 2 feet high: lower leaves and petioles pilose with spreading yellowish hairs, upper leaves with peduncles sulcate, pubescence appressed: leaves subpinnate, nearly as narrow as in *R. repens:* sepals reflexed; petals narrow; receptacle pilose: akenes oblique, roundly obovate, laterally margined, marked with minute impressions and often a few scattered tubercles on sides, acuminate; base of style persistent: head of fruit globose. Allied to *R. acris* in habit and roots; to *R. repens* in foliage. Its narrow often numerous petals and reflexed calyx remove it from all. Vera Cruz, Oaxaca, in San Miquelito Mts., and other places in Mexico. Common in grass lands.

14. **R. pilosus** H.B.K. Nov. Gen. & Sp. 5: 36. 1821.

Roots thick-fibrous, many: stem ascending, somewhat dichotomously branched above, hirsute: radical leaves petiolate, ternate, appressed-pilose, 10 to 15 lines wide, 1 to 1½ inches long; leaflets cut-toothed, lateral ones sessile, ovate-rhomboid, sometimes 2–3-lobed; terminal leaflets large, on stalks 2 to 6 lines long, subrotund, 3-lobed or 3-parted; lower stem leaf like the radical leaves but much dissected, short-petioled; upper stem leaves gradually less dissected, those near the flowers sessile: flowers as large as in *R. bulbosus*, peduncles silky; sepals 5, ovate, acutish, pubescent outside, reflexed, much shorter than the petals, deciduous; petals 5 (rarely 6), oblong, with rounded tips, 5 lines long, glabrous, supplied with a scale on the claw: akenes glabrous, oblong to obovate, compressed, tapering into the persistent style; fruit in globose head. High altitudes, Guatemala. Also near Bogota, U. S. of Colombia.

15. **R. Bloomeri** WATS. Bot. Calif. **2**: 426. 1880.

R. Chilensis HOOK. & ARN. Bot. Beech. 134. 1841.

Stem ascending, 1 to 2 feet long, sparsely hairy or becoming glabrous: radical leaves bright green, long-petioled, some broadly cordate or ovate, coarsely dentate or incised, others 3-parted, some divided into 3 leaflets which are short-stalked and the middle one often 3-lobed; stem leaves short petioled: petals yellow, 6 lines long, emarginate; sepals shorter: akenes glabrous, 2 lines long, turgid; beak slender, subulate, persistent. San Francisco bay.

16. **R. hispidus** MICHX. Fl. **1**: 321. 1803.

R. Marilandicus POIR. in Lam. Encycl. **6**: 126. 1804.

R. repens var. *Marilandicus* TORR. & GRAY, Fl. **1**: 21. 1838.

R. fascicularis BRITTON, Pl. N. J. 3. 1881.

Appressed-pubescent, when young densely villous: stems slender, ascending or spreading, ½ to 2 feet long: leaves palmately 3-parted, or pedately or pinnately 3–5-divided; the divisions ovate, or variable, middle one often stalked, others usually sessile; all often cuneate at base, sharply cleft or lobed: petals 5 or more, light yellow, 3 to 6 lines long; sepals half as long, spreading: akenes broadly oval, lenticular, margined, abruptly tipped; beak half their length, subulate, slightly curved; head ovoid to globose. Earliest spring. Canada through Eastern and Middle States to Florida and Arkansas.

17. **R. bulbosus** LINN. Sp. Pl. 554. 1753.

R. speciosus HORT. ex VILM. Fl. Pl. Terre 1 ed. 722. 1865.

Plant from a true bulb, erect, about 1 foot high, hairy: leaves petioled, 3–5-parted, the divisions sometimes stalked, segments lobed: flowers terminating the branches, bright yellow, large; petals large, obovate, shining above; sepals much smaller, often reflexed: akenes compressed, with short beak, borne in a globose head. Spring and summer. Persia, Europe, northern Africa. The double form is perhaps best suited for culture.

18. **R. Icelandicus** n. sp.

Caudex short, roots fibrous: plant pubescent throughout: no true stem, scape about 3 inches high, nearly erect, slender: leaves about 1 inch long on petioles the same length, blade 3-divided or parted, the leaflets sessile or the middle one stalked; segments with about 3 entire or toothed cuneate lobes: petals 5, yellow, large, obovate-cuneate, obcordate or retuse; sepals shorter, spreading, pubescent: carpels much like those of *R. acris*. Collected June, 1895, by Elizabeth Taylor at Seydisfjordr, Iceland.

19. **R. orthorhynchus** HOOK. ex GRAY, Proc. Am. Acad. **21**: 377. 1887.

R. ornithorhynchus WALP. Rep. **1**: 43. 1842 (by error).

Root thick fibrous: plant 10 to 18 inches high, erect, branched, hirsute to nearly glabrous: leaves oblong in outline, pinnately compound; 5 to 7 leaflets cleft and incised, quite variable; upder leaflets often confluent and sessile or nearly so, lower ones well stalked: petals 7 to 16, yellow, rarely purple beneath, obovate, 4 to 6 lines long; sepals much shorter, pubescent beneath, reflexed, deciduous: akenes glabrous, obliquely ovoid, compressed, 1 to 2 lines long, margined; style of same length, straight, rigid, persistent: head globose. May to July. Wet places. British Columbia to western Oregon and Montana. Cultivated.

Var. **platyphyllus** GRAY, Proc. Am. Acad. **21**: 377. 1886.

R. macranthus WATS. Bot. King Exp. 9. 1871. Not Scheele.

R. maximus GREENE, Bull. Torr. Club, **14**: 118. 1887.

Often 3 feet or more high: leaves larger, 2 to 4 inches across, the leaflets often 3 inches long, and laciniately cut: petals often larger than the type. Wasatch Mountains, northern Utah, Pyramid lake, northern Nevada, northern California, Washington, Idaho. Cultivated.

20. **R. dichotomus** MOC. & SESSE. ex DC. Syst. **1**: 288. 1818.

Stem erect, often dichotomously branched: radical leaves very long-petioled, bipinnate: flowers yellow; sepals reflexed: akenes with acuminate erect beaks. Mexico.

21. **R. Llavænus** SCHLECHT. in Linnæa, **10**: 233. 1836.

Stem prostrate, the flowers on erect or ascending branches, terminal: leaves 3-divided and again 3-lobed, segments narrowly and sharply cut-toothed; middle leaflet stalked, lateral ones sessile, all cuneate at base; the long petioles hirsute, widely sheathing and smooth at the base: peduncles sulcate; receptacle pilose: flowers yellow; calyx reflexed: akenes obliquely round-obovate, slightly margined laterally, terminated by the long erect style, smooth: head of fruit globose. June to July. Meadows, Jalapa, Vera Cruz. Allied to *R. dichotomus*, leaves nearly as finely dissected, yet much allied to *R. Hookeri.*

22. **R. macranthus** Scheele, in Linnæa, **21**: 585. 1848.
R. repens var. *macranthus* Gray, Pl. Lindh. **2**: 141. 1850.

Plant hairy; erect or spreading, ½ to 3 feet high: leaves 3–5-divided, the middle leaflet longer stalked than the others, lobed and cleft into narrower segments than in *R. septentrionalis:* petals 7 to 16, yellow, 5 to 7 lines or longer, oblong to obovate; sepals shorter, spreading: receptacle hairy: akenes flat, ovate to orbicular, widely margined; style subulate, long, often only partly persistent: head large, slightly lengthened. Texas, southwestern Arizona into Sonora, Mex.

23. **R. subalpinus** n. n.
R. delphinifolius H.B.K. Nov. Gen. & Sp. **5**: 38. 1821. Not Torr.

Roots fibrous: stem erect, branched above, few-flowered, silky-hairy: radical leaves long-petioled, pilose on both sides, ternate, lateral leaflets subsessile, 2-parted, terminal one well stalked, 3-parted, segments 2–3-lobed, incised and toothed; lobes lanceolate; stem leaves similar but smaller, short-petioled: flowers on long peduncles, erect, as large as in *R. bulbosus;* sepals 5, silky outside, reflexed, ovate, acutish, yellowish, much shorter than the corolla; petals about 15 (*fide* Bonpl.), yellow, glabrous, 5 lines long, spatulate-oblong, apex rounded, claw furnished with a scale: young ovaries many, small, sessile, ovate to subrotund, compressed, glabrous; style long and slender. May. Moist places. Altitude 8,000 to 9,000 feet. San Miguelito Mountains and at Guanajuato, Mex.

24. **R. canus** Benth. Pl. Hartw. 294. 1848.
R. Californicus var. *canus* Wats. Bot. Calif. **1**: 8. 1876.

Plant canescent when young but often becoming green and sparingly villous; erect or ascending, rather large, 1 to 2 feet high: leaves with mostly 3 or more divisions; the middle one stalked; leaflets cuneate, 2–3-cleft and again incised: petals yellow, 5 to 6 lines long, obovate; sepals half as long, reflexed, soft-hairy: akenes about 2½ lines long; beak less than half as long, broad, hooked. Sacramento valley, Calif.

Var. **Blankinshipii** ROBINSON, Syn. Fl. 1: 1: 35. 1895.
The silky coat persistent but less dense than in the typical plants: akenes plainly hispid and papillose. Capay, Yolo County, Calif.

Var. **hesperoxys** n. var.
R. hesperoxys GREENE, Erythea, 2: 189. 1894.
Plants much greener than the type; doubtless due to the early falling of the canescence. California.

25. **R. amarillo** BERTOL. Fl. Guat. 24. 1840.

Hirsute, stem branched, ascending: lower leaves petioled; leaves compound; leaflets stalked, subcordate-ovate, acute, 3-lobed, cut-toothed; the upper leaves often short-petioled, ternate, divisions lanceolate, dentate: petals about 8, yellow, oblong-cuneate; sepals shorter, hairy, reflexed; flowers as large as *R. acris:* akenes compressed, glabrous; style long, erect but recurved at tip: head of fruit globose. Guatemala.

26. **R. repens** LINN. Sp. Pl. 554. 1753.
R. prostratus POIR. in Lam. Encycl. 6: 113. 1804.
R. Clintonii BECK. Bot. 9. 1833.

Roots fibrous: plant more or less hairy; spreading by runners; flower stems often ascending 6 to 12 inches: leaves petioled, 3-divided; middle leaflet or all of them stalked, often again 3-lobed or cleft, and somewhat coarse toothed, bases cuneate or truncate: petals obovate, 5 to 6 lines long; sepals much shorter, spreading, hairy below: akenes compressed, margined; beak short, stout, slightly bent: head globose. May to July. Common. Nova Scotia and Newfoundland to Virginia, westward. Also Europe and Asia. Cultivated.

27. **R. palmatus** ELL. Sketch, 2: 61. 1824.

Included by Gray, '86, with *R. septentrionalis* which it is much like; plant smaller, more decumbent; runners often long: leaves 1 inch across, thin, somewhat 3-parted or divided, divisions ovate, coarsely few-toothed; lowest leaves often subentire: flowers 6 lines broad. Pine lands and swampy places, Tennessee, South Carolina, Florida.

28. **R. Aschenbornianus** SCHAU. in Linnæa, **20**: 719. 1847.

Stem erect, many-flowered: leaves hairy to subhirsute; radical leaves long-petioled, ternate to bipinnate, the pinnules 3-parted to many lobed, the lobes nearly linear; peduncles silky: sepals reflexed: receptacle subpilose: akenes com pressed, slightly margined, smooth, with fine impressions or punctures, style straight: fruit in a globose head. Mountains of Mexico near "Tutam."

29. **R. acriformis** GRAY, Proc. Am. Acad. **21**: 374. 1886.

R. acris HOOK. Fl. **1**: 18. 1829 (partly).

Plant with short rather appressed pubescence, slender, erect, 1 foot or more in height: leaves all 3–7-parted or divided; divisions 2–3-cleft or lobed, into lanceolate or linear segments which are often entire: petals yellow, roundly obovate, about 3 lines long; sepals about half as long, spreading or becoming reflexed: akene 1 to 2 lines long: beak half as long, curved. Eastern Rockies in Alberta; Montana, Wyoming; wet places. Southern Colorado at 10,000 feet.

R. Montanensis Rydb. Mem. N. Y. Bot. Gard. **1**: 166, 1900, is a form with beak more slender and more curved.

30. **R. Californicus** BENTH. Pl. Hartw. 295. 1848.

R. acris var. *Deppii* NUTT. ex Torr. & Gray, Fl. **1**: 21. 1838.

R. delphinifolius TORR. & GRAY, Fl. **1**: 659. 1838. Not Torr.

R. dissectus HOOK. &. ARN. Bot. Beech. 316. 1841. Not Bieb.

R. regulosus GREENE, Pitt. **2**: 58. 1890.

Roots fibrous: plant rather weak, ½ to 2 feet high, usually pubescent or hirsute; branching and without leaves in upper part: leaves ternately divided or parted, or palmately 5-divided into linear or narrow often 2–3-parted divisions: petals 6 to 15, glossy yellow, oblong or narrowly obovate, 4 to 6 lines long: akenes flat, slightly margined, nearly 2 lines long: beak very short. Rather dry places. Western California and adjacent Oregon, common. Cultivated.

Var. **Ludovicianus** (GREENE).

R. Ludovicianus GREENE, Bull. Cal. Acad. Sci. **2**: 58. Mch. 6 1886.

R. Californicus var. *latilobus* GRAY, Proc. Am. Acad. **21**: 375. 1886.

Basal leaves 3-parted, divisions broadly or narrowly cuneate, incisely cleft or laciniate: stem leaves not so much dissected. Southern California.

Var. **crassifolius** GREENE, Erythea, **1**: 125. 1893.

Stout and low, sparingly villous throughout: lower leaves not so deeply parted as the type, coarsely toothed; stem leaves mostly deeply parted into 3 oval or oblong quite entire segments: flowers and akenes larger than in the type. Ft. Bragg, Mendocino Co., Calif.

31. **R. Asiaticus** Linn. Sp. Pl. 552. 1753.

Roots fleshy: plant erect, either simple or branched, ½ to 1 foot high: leaves petiolate, becoming sessile toward the top, ternate or biternate; segments toothed or deeply 3-lobed; flowers terminating in the stems and branches, variable in color: calyx spreading, becoming reflexed; petals large, obovate, blunt: fruits in spike. May to June. Asia Minor. Flor. des Serr. **16**: 1679 (fl–pl). Revue Hort. Belg. **1890**: 133 (var. *superbissimus*). Sibth. Fl. Gr. 518. The cultivated forms of this species are constantly increasing in number. They are of two main types: (1) The florist's section called Persian Ranunculi or true *R. Asiaticus*. (2) The gardener's section, called Pivoine and Turban Ranunculi, or var. *Africanus*. There are many named forms of each in the American trade.

32. **R. abortivus** LINN. Sp. Pl. 551. 1753.
R. nitidus WALT. Car. 159. 1788.

Sparingly pubescent or quite glabrous, one-half to 2 feet high, branched: stem leaves sessile or short-petioled, once or twice 3-parted or lobed, segments oblong or linear, somewhat cuneate; lower leaves long-petioled, lucid green, crenate or lobed, broadly cordate, roundish, or ovate: petals pale yellow, hardly over a line long; sepals longer and larger, reflexed; receptacle short, pubescent: akenes compressed, glabrous, tipped with the minute, curved beak: head small, globose. Spring. Moist grounds and woods. Labrador to Florida, north and west to Colorado and British Columbia. Var. *eucyclus* FERNALD, Rhodora, **1**: 52, 1899, a slender, flexuose form with thinner, glossy, orbicular, radical leaves.

Var. **Harveyi** GRAY, Proc. Am. Acad. **21**: 372. 1886.

R. abortivus var. *grandiflorus* ENGELM. ex Branner & Coville, Ark. Geol. Surv. **6**: 162. 1891.

R. Harveyi BRITTON, Mem. Torr. Club, **5**: 159. 1894.

Stem and foliage more slender and roots often thicker than in the type: plant somewhat pubescent: petals of the extreme forms 3 lines long and much longer than the sepals: akenes sometimes few, large and in a globose head, but varying to those of the type. Damp rocks, Arkansas to St. Louis, Mo.

Var. **australis** BRAND. Zoe **4**: 399. 1894.

Lower leaves large, reniform: petals 2 to 3 lines long; flowering in August. Abundant in wet places, high summits of Sierra de la Laguna and San Fransisquito, Lower California.

33. **R. sceleratus** LINN. Sp. Pl. 551. 1753.

Stems stout, hollow: plant glabrous or nearly so, one-half to 2 feet high, branching: radical and lower stem leaves thick, long-petioled, 3–5-lobed, reniform or cordate; lobes cuneate, crenately incised or cleft; upper stem leaves sessile or petioled, deeply lobed or parted; the lobes cuneate-oblong or linear, toothed or entire: petals 1 to 2 lines long, yellow; sepals often a little shorter: akenes numerous, very small, compressed, glabrous, barely apiculate: head oblong. April to Aug. Wet ditches and shallow water. New Brunswick to Florida and somewhat westward. Europe and Asia.

34. **R. eremogenes** GREENE, Erythea, **4**: 121. 1896.

R. sceleratus var. *multifidus* NUTT. ex Torr. & Gray, Fl. **1**: 19. 1838.

Leaves more dissected than *R. sceleratus:* stem nearly leafless: head of akenes nearly globose or ovate, large. Habitat of that species, eastern base of Rockies in Colorado to the Sierra Nevadas, to northwest British America and south to Arizona.

Var. **degener** GREENE, Pitt. **4**: 144. 1900.

Stems several, short, ascending: roots coarser than in the type: akenes with no marginal development: head more rounded. Southern Colorado.

35. **R. Allegheniensis** BRITTON, Bull. Torr. Club, **22**: 224. 1895.

R. abortivus HOOK. Fl. **1**: 15. 1829. In part.

This is also closely allied to *R. abortivus* in habit and foliage. Plant glabrous, not lucid: akenes slightly compressed and margined, tipped with subulate hooked or recurved styles hardly half their length. April, May, North Carolina, Virginia, Massachusetts.

36. **R. recurvatus** Poir. in Lam. Encycl. **6**: 125. 1804.
R. lanuginosus Walt. Car. 159. 1788. Not Linn.
R. saniculæformis Muhl. Cat. 54. 1813.
R. tomentosus Spreng. Neue Entd. **1**: 287. 1820.

Plant hirsute or only slightly hairy, erect, ½ to 2 feet high, branching: all the leaves petioled and never divided to the base, 1½ to 3 inches wide, deeply 3-cleft, the lobes broadly cuneate, acute, toothed or lobed: petals light yellow, about 2 lines long; sepals of same length or little longer: akenes compressed, margined: beak one-half their length, recurved. Damp woods, Nova Scotia to Lake of the Woods, south to Missouri and Florida.

37. **R. Bongardi** Greene, Erythea, **3**: 54. 1895.
R. occidentalis var. *parviflorus* Torr. Bot. Wilkes Exp. 214. 1854.
R. occidentalis var. *Lyalli* Gray, Proc. Am. Acad. **21**: 373. 1886. Not *R. Lyalli* Hook. f.
R. tenellus var. *Lyalli* Robinson, Syn. Fl. **1**: **1**: 33. 1895.
R. Greenei Howell, Fl. N. W. Am. **1**: 18. 1897.
R. Earlei Greene, Pitt. **4**: 15. 1899.
R. Lyalli Rydb. Mem. N. Y. Bot. Gard. **1**: 166. 1900.

Much like the following variety which is better known and was formerly considered the type. Plant more hirsute: leaf segments much broader: petals rather of the larger size, somewhat persistent: akenes somewhat hispid; styles rather long. Northern California to Colorada and Montana and to Fort Wrangel, Alaska.

Var. **Douglasii** (Howell).
R. recurvatus Bong. Veg. Sitch. 123. 1831. Mainly, not Poir.
R. tenellus Nutt. ex Torr. & Gray Fl. **1**: 23. 1838. Not Viviani.
R. Nelsoni var. *tenellus* Gray, Proc. Am. Acad. **8**: 374. 1872.

R. occidentalis var. *tenellus* GRAY, Proc. Am. Acad. **21**: 373. 1886.
R. occidentalis var. *Eiseni* GRAY, l. c. (in small part).
R. Nelsoni var. *glabriusculus* HOLZINGER, Cont. Nat. Herb. **3**: 210. 1895. Not *R. glabriusculus* Rupr.
R. Bongardi var. *tenellus* GREENE, Erythea, **3**: 54. 1895.
R. Douglasii HOWELL, Fl. N. W. Am. **1**: 18. Mch. 15. 1897.
R. arcuatus HELLER, Bull. Torr. Club, **24**: 310. June 29. 1897.

Slender, erect, usually over one foot high, slightly pubescent or glabrous, hirsute on petioles and peduncles: leaves deeply 3–5-cleft; segments broadly cuneate to oblanceolate, coarsely toothed: petals 1 to 2 lines long; receptacle glabrous: akenes compressed, glabrous, semi-oval; styles persistent, circinate-revolute; head small, globose. Southern California, Idaho, to Alaska.

38. **R. occidentalis** NUTT. ex Torr. & Gray, Fl. **1**: 22. 1838.
R. recurvatus var. *Nelsoni* DC. Syst. **1**: 190. 1818.
R. recurvatus (2 forms) SCHLECHT. Animad. Ranunc. **2**: 28. 1820.
R. Schlechtendalii HOOK. Fl. **1**: 21. 1829. (As to plant.)
R. Nelsoni GRAY, Proc. Am. Acad. **8**: 374. 1872.
R. Eiseni KELLOGG, Proc. Calif. Acad. Sci. **7**: 115. 1877.
R. occidentalis var. *Eiseni* GRAY, Proc. Am. Acad. **21**: 373. 1886 (mainly).
R. occidentalis var. *brevistylus* GREENE, Pitt. **3**: 14. 1896.

Plant villous with spreading hairs, 5 to 18 inches high: lower leaves petioled, round cordate, 3–5-cleft or parted; segments cuneate-obovate, often 2–3-cleft and cut; some leaves 3-divided with the leaflets stalked; upper stem leaves smaller with lanceolate segments: petals yellow, large, spreading; sepals half as long, reflexed: akenes glabrous or sparsely bristled: style flattened, subulate, hooked, half as long as akenes; receptacle glabrous: head of fruit ovoid. Low open places. Alaska to Montana and California.

Var. **Howellii** GREENE, Pitt. **3**: 14. 1896.
R. Howellii GREENE, ex Howell, Fl. N. W. Am. **1**: 17. 1897.

Rather leafy; upper leaves more deeply and repeatedly cleft: styles longer, slender, subulate, nearly straight. Dry hills, Ashland, Oregon, southward toward Klamath river, Calif.

Var. **ultramontanus** GREENE, Pitt. 3: 13. 1896.

Plant tufted; divisions of lower leaves not cuneiform, deeply cleft into lanceolate segments; upper ones lanceolate, entire: several flowers ½ inch across: styles hooked. Moist places, Truckee river, east of Sierras, Calif.

Var. **Rattani** GRAY, Proc. Am. Acad. 21: 373. 1886.

R. Rattani HOWELL, Fl. N. W. Am. 1: 17. 1897.

R. ciliosus HOWELL, l. c.

Differs from the type in having the akenes covered with short, stiff hairs and also roughened with papillæ. Josephine county, Ore., to central California.

Var. **robustus** GRAY, Proc. Am. Acad. 21: 373. 1886.

R. occidentalis GRAY, Proc. Am. Acad. 8: 374. 1872.

Stem stout, often a foot high: flowers large, 9 to 15 lines long, long-peduncled: petals broadly obovate: akenes numerous, very large. Unalaska and islands westward.

39. **R. Turneri** GREENE, Pitt. 2: 296. 1892, except syn.

Plant appearing much like a tall specimen of *R. occidentalis:* petals longer, 4 to 7 lines long: flowers long-peduncled: more akenes in a head; styles circinately-revolute, strongly so. Porcupine river, Alaska.

40. **R. acris** LINN. Sp. Pl. 554. 1753.

Plant hairy up to the sepals, erect, ½ to 3 feet high, often branched: radical leaves on long slender petioles; others with shorter petioles sheathing the stem, or nearly sessile: leaves 3-parted nearly to the base, the divisions ovoid-cuneate, 2–3-lobed and coarsely toothed or cut; bracts linear, lobed or entire: flowers yellow, 9 to 12 lines across, several, on rather short peduncles; sepals hairy beneath, ovate, shorter than the petals; petals 5, glabrous, obovoid, obtuse, bearing a prominent scale at base: akenes compressed, coriaceous on margins; style very short: head globose. May to September. Newfoundland, Canada, Eastern States. Said to be naturalized from Europe. Var. *flore-pleno* HORT. is more used in the trade. Bot. Mag. 215.

41. **R. McCallai** n. sp.

Stem erect, slender, 12 to 20 inches high, branched toward the top, somewhat pubescent: radical leaves hairy, on slender hairy peduncles 2 to 4 inches long; blade 3–5-parted nearly or quite to the base, segments less than 1 inch long, cuneate, divergent, cleft into 2 to 3 linear lobes; stem leaves none or bract-like, subtending the branches, or a small one near the middle: flowers 2 to 6, large, yellow; petals 5, obovate, entire or obcordate; sepals shorter, spreading, hairy: carpels ovate in a globose head; styles subulate, hooked: receptacle glabrous. Collected by W. A. McCalla (2113) near Banff, Alberta, Canada, July, 1899, in wet meadows. Differs from *R. acris* in its leaves, usually naked stem, etc.

42. **R. pedatifidus** J. E. SMITH in Rees' Cycl. No. 72. 1813–16.

R. arcticus RICHARDS. in Frankl. 1st Journ. 1 ed. App. 741. 1823.

R. affinis R. BR. Parry 1st Voy. App. 265. 1824.

R. amœnus LEDEB. Fl. Alt. **2**: 320. 1830.

R. auricomus HOOK. f. Arc. Pl. 283, 312. 1862.

Plant sparsely hairy, 3 to 15 inches high, slender, sometimes branched: radical and lower stem leaves petioled, broadly ovate, crenate, toothed, lobed, or cleft nearly to the base into segments which are often narrow; upper stem leaves deeply cleft, nearly sessile, lobes narrow: petals yellow, 3 to 4 lines long; sepals shorter, pubescent beneath: akenes often hairy, with short beak: head oblong to cylindric. Quebec to Arctic regions, west to Alaska; Rockies to Colorado and Arizona. Ledeb. Ic. *t. 113*.

Var. **cardiophyllus** BRITTON, Bull. Torr. Club, **18**: 265. 1891.

R. cardiophyllus HOOK. Fl. **1**: 14, and vars. *t. 6*. 1829.

R. affinis var. *lasiocarpus* TORR. Bot. Wilkes Exp. 213. 1854.

R. affinis var. *leiocarpus* TRAUT. ex Midden. Reise in Sibir. 62. 1856.

R. affinis var. *cardiophyllus* GRAY, Proc. Am. Acad. Phil. **1863**: 56.

R. affinis var. *validus* GRAY, Proc. Am. Acad. **21**: 371. 1886.

R. affinis var. *micropetalus* GREENE, Pitt. 2: 110. 1890.
R. Arizonicus var. *subaffinis* GREENE, l. c. 60. Not Gray.
R. inamœnus GREENE, Pitt. 3: 91. 1896.

Differs from the type in its stouter habit, radical leaves often cordate at base, usually not much lobed, but variable: flowers larger: akenes either hairy or glabrous. New Mexico and Arizona to Montana, east to Labrador.

Var. **pinetorum** (GREENE).
R. cardiophyllus var. *pinetorum* GREENE, Pitt. 4: 144. 1900.

Stem short, canescently villous: roots strongly and copiously developed: leaves oval, often subcordate, or truncate at base, margins crenate: flower 1 inch across: head of akenes not so long as in the type, ovoid or globose. Pine woods, Graham's Park, southern Colorado. 7,800 feet.

43. **R. vicinalis** GREENE, Pitt. 4: 145. 1900.

This is an Alaskan plant from the region of Fort Selkirk, which differs from *R. pedatifidus* in its larger flowers, and in having the radical leaves cleft or parted into about 7 lobes, and these again 3-cleft. But we find this leaf character in some Colorado forms of that type.

44. **R. Eschscholtzii** SCHLECHT. Animad. Ranunc. 2: 16. *t. 1.* 1819.
R. nivalis var. *Eschscholtzii* WATS. Bot. King Exp. 8. 1871.
R. ocreatus GREENE, Pitt. 4: 15. 1899.

Caudex short, oblique, roots fibrous: plant slightly hairy, 3–8 inches high: leaves roundish or broader in outline ; stem leaves 3–5-lobed or parted, lobes lanceolate to oblong or linear spatulate ; basal leaves with broader lobes, or lobed like the others: flowers 1 to 3 ; petals yellow, broadly obovate, sometimes slightly crenulate or obcordate, 3 to 6 lines long ; sepals pubescent beneath: akenes lenticular, margined, glabrous ; beak sharp, straight or sometimes recurved: head of fruit oblong or nearly globose. North Alaska in mountains to southern California, east to Colorado.

45. **R. eximius** GREENE, Erythea, 3: 19. 1895.
R. alpeophilus A. NELSON, Bull. Torr. Club, 26: 350. 1899.

Much like *R. Eschscholtzii*, but often larger, nearly glabrous :

radical leaves broader, less divided; upper leaves with lobes 1–2 inches long: sepals nearly glabrous: akenes broadly oval or obovate. Mountains of Wyoming, Idaho, Colorado.

46. **R. saxicola** RYDB., Mem. N. Y. Bot. Gard. **1**: 164. 1900. Allied to *R. Suksdorfii;* differs slightly in the form of the lower leaves, which are often more reniform-flabellate: akenes pubescent: head of fruit oblong. Cedar mountain and Mill Creek, Montana, Yellowstone Park.

47. **R. Suksdorfii** GRAY, Proc. Am. Acad. **21**: 371. 1886. Roots fibrous: stems slender, 3 to 6 inches high, glabrous: radical and lowest stem leaves small, about 6 to 8 lines long, subreniform to broadly flabelliform with truncate base, deeply 3–5-cleft or parted; divisons cuneate, again 3–5-cleft or incised; upper stem leaves with linear divisions: flowers 1 to 3, deep yellow; petals round obovate, retuse, 4 to 6 lines long: akenes turgid-lenticular, sharp-edged, glabrous; style persistent for a time, slender, ¾ line long, equalling the akene body: head of fruit globular. July to Aug. Damp places, 6,000 to 8,000 feet alt. Olympic mountains, Mt. Rainier, Mt. Adams east to the Blue mountains, Oregon and into Montana. Cultivated.

48. **R. ovalis** RAF. Proc. Dec. 36. 1814.

R. rhomboideus GOLDIE, Edin. Phil. Journ. **6**: 329. *t. 11. f. 1.* 1822.

R. brevicaulis HOOK. Fl. **1**: 13. *t. 7.* 1829.

R. auricomus var. *Cassubicus* E. MEYER Pl. Labr. 96. 1830.

Pubescent, 3 to 15 inches high: radical and lower leaves roundish to ovate-oblong, crenate, or slightly lobed, base truncate or cuneate, petioled, 3–7-divided, lobes linear or oblong: petals yellow, narrow, 3 to 6 lines long; sepals much shorter: akenes oval, minutely beaked: head of fruit globose. Wisconsin and northern Illinois, north to Labrador and the Northwest Territory.

49. **R. Arizonicus** LEMMON ex Gray, Proc. Am. Acad. **21**: 370. 1886.

R. affinis TORR. Bot. Mex. Bound. 29. 1858. (In part.)

Roots fascicled, somewhat thickened: plant glabrous or with soft-villous hairs below, 6 to 12 inches high: radical leaves oval to oblong, cordate, crenate-dentate; the later ones often 5-cleft and again 3–5-lobed; stem leaves 1–3-ternate with narrow linear divisions: petals yellow, often 6 to 7, ovate to oblong, 3 to 5 lines long: akenes compressed, thin-margined, pubescent: head small, globose. Willow Spring, and mountains of southern Arizona.

Var. **subaffinis** GRAY, Proc. Am. Acad. **21**: 370. 1886.

R. Arizonicus GREENE, Pitt. **2**: 60. 1890.

R. subsagittatus var. *subaffinis* GREENE, Pitt. **2**: 110. 1890.

R. subaffinis RYDB. Bull. Torr. Club, **24**: 246. 1897.

Plant lower than the type, usually 1-flowered: akenes densely pubescent, with subulate style nearly their own length: head of fruit oval. High altitudes. Mt. Agassiz, in San Francisco, mountains of Arizona. Also Chihuahua.

Var. **subsagittatus** GRAY, Proc. Am. Acad. **21**: 370. 1886. Stouter than the above; villous at least at first: stem simple, few-flowered: radical leaves thick, oblong, bases subcordate to sagittate: petals broader than in the type: head of akenes larger, oval. Wet ground. Northern Arizona to San Francisco mountains.

50. **R. montanus** WILLD. Sp. Pl. **2**: 1321. 1799.

Rootstock creeping, 1–3 inches long, ⅓ inch thick: plant 6 inches high, pubescent with soft appressed or spreading hairs, especially toward the top: radical leaves few, petiolate, smooth, orbicular in outline, 3-parted, and lobed into blunt, toothed segments; stem leaves sessile or nearly so, clasping the stem, 3–5-parted into narrow somewhat toothed or entire lobes: flowers solitary, terminating the simple or once-branched stem, 1 inch or larger; sepals concave, acute, yellowish-green, slightly hairy; petals 5, large, broadly obovoid, bright yellow, with small scale and pore at base: akenes turgid, glabrous; beak strongly hooked, puberulent. May to July. Europe. Cultivated. Bot. Mag. 3022. Bot. Cab. 1610.

Var. **dentatus** BAUMG. Enum. Stirp. Magn. Trans. **2**: 124. About 1823.

R. carpaticus Herbich. Sel. Pl. Rar. Galic 15. 1836.

Leaves much more toothed than in the type: plant much taller: flowers larger. Cultivated. Bot. Mag. 7266. Garden **52**: 1138.

51. 1809. **R. corthusæfolius** WILLD. Enum. Hort. Berol. 588.

Root of thick, fleshy, fasciculated fibers: plant velvety hairy, 1 to 3 feet high: lower leaves long-petioled, roundish to reniform, incised, and with cut and toothed lobes; stem leaves divided into 3 to 5 narrow lobes; upper ones sessile: flowers several or many, terminal and axillary, rather paniculate; sepals 5, ovate to lanceolate, green with pale margins; petals 5, large, broadly obovate, glossy yellow: akenes compressed, hairy on sides, tapering into recurved styles nearly their own length: head of fruit short oval. May, Island of Teneriffe, Canary group. Garden, 45: 944. Bot. Mag. 4625. Not very hardy, and needs protection in winter and early spring. It is well suited for pot culture. It is increased by division of the roots in autumn.

52. **R. longipedunculatus** SCHEIDW. in Hortic. Belge. **5**: 163. *t. 9.* 1838.

Roots fibrous: stem slender, weak, scapose, often once branched near the base: plant pilose with yellowish hairs: radical leaves 3-lobed, middle lobe trifid, otherwise mostly entire; true stem leaves wanting or very low; petioles 1 to 1½ inches long: peduncles 4 to 5 inches long, slender, erect or ascending, bibracteate: flowers 1 or 2, terminal; petals 12 to 15, oblong-lanceolate, acutish, yellow; sepals reflexed. Wet places, Real del Monte, north of Mexico City.

53. **R. Donianus** PRITZ. ex Walp. Rep. **2**: 740. 1843.
R. humilis D. DON, ex G. Don, Gen. Syst. **1**: 34. 1831. Not Pers. 1807.

Short, 1 to 3 inches high, pilose: radical leaves stalked, cordate, obtuse, slightly 3-lobed and crenate: peduncles long, radical, axillary and terminal: flowers small, yellow: carpels rather inflated, beaked. Mexico.

54. **R. multicaulis** D. DON, ex G. Don, Gen. Syst. **1**: 34. 1831.

Plant about 3 to 4 inches high, pilose: stems numerous, prostrate or ascending: radical leaves petioled, cordate-roundish, 3-lobed; lobes crenate: stem leaves sessile, entire, opposite or apparently so: flowers yellow, medium size; petals emarginate, much longer than the sepals which are reflexed: carpels rather inflated, pointed: head of fruit ovate. Mexico.

55. **R. Mexicanus** n. n.
R. geoides H.B.K. Nov. Gen. and Sp. **5**: 37. *t. 429.* 1821. Not Siev. 1794.

Roots fibrous: stem 5 to 8 inches high, simple or branched low; plant silky pubescent up to and including under side of sepals: radical leaves 3-parted nearly to midrib: divisions toothed or incised, ovate-cuneate; petiole 1 to 2 inches long; stem leaf with 3 to 5 narrow segments, sessile or on petiole sheathing the stem; bracts linear: flowers (rarely 2 to 3), large, terminating long, erect peduncles; sepals 5, ovate, much shorter than petals, reflexed; petals 10, spatulate oblong, rather obtuse, 5–7 lines long, spreading, claw provided with nectar pit and scale: akenes compressed, smooth; style as long as akene body, persistent for a time, erect. May. Real del Monte, north of Mexico City; Guajuco, Nuevo Leon, northern Mexico.

56. **R. uncinatus** D. Don ex G. Don, Gen. Syst. **1**: 35. 1831.

Roots fibrous: stem erect, 1 foot high: plant glabrous: radical leaves not seen; stem leaves long-petioled, 3-parted, segments 3-lobed; lobes toothed or again lobed, acute; leaves near the flower ternate, leaflets linear-lanceolate, acute, quite entire: flowers small, yellow, terminal and lateral, on slender peduncles: akenes few, ending in hooked beaks: head globose. Mexico.

57. **R. petiolaris** H.B.K. Nov. Gen. and Sp. **5**: 36. *t. 428.* 1821.

Roots fibrous: stem erect, striate, puberulent, somewhat branched above, about 6-flowered: radical leaves on petioles 6 to 7 inches long, 3-parted nearly to the midrib; the divisions often 2–3-lobed and incised; the lobes often somewhat oblong-cuneate, deep green and appressed-pubescent above, pale and appressed-pilose beneath; stem leaves short-petioled, smaller and with much more slender lobes; bracts linear-lanceolate, lobed or entire; base of petioles membranaceous, somewhat sheathing: flowers medium size, on erect peduncles which are pilose; sepals 5, ovate-oblong, acute, pilose beneath, shorter than the petals, reflexed, deciduous; petals 5, obovate, rounded at the end, a claw and scale at base, yellow, glabrous, about 4 lines long, much exceeding the stamens: akenes oblique, compressed, glabrous, rather abruptly joined to the short, persistent style: head of fruit subglobose. September. Near "Los Joares"; and Santa Rosa, state of Mexico. Altitude, 8,400 feet.

58. **R. adoneus** GRAY, Proc. Acad. Phila. **1863**: 56.
R. amœnus GRAY, Am. Journ. Sci. Ser. 2, **33**: 241. 1862. Not Ledeb.
R. orthorynchus var. *alpinus* WATS. Bot. King Exp. 9. 1871.

Root slender-fibrous: plant shaggy-hairy, 4 to 12 inches high, sometimes becoming decumbent: leaves usually 2–3-times 3-parted and lobed, lobes all narrow-linear, acute; primary divisions of leaves sessile or nearly so; petioles of basal leaves membranous in lower part; stem leaves sessile or on a sheathing base, usually borne opposite resembling an involucre: petals 5 (or 6 to 8), large, yellow, rounded outwardly, cuneate at base, 6 lines long, much exceeding the lanceolate sepals which are hairy beneath: akenes somewhat compressed, acutish: style long, straight, subulate; head globular to oblong. Summer. Rockies of Colorado. Altitude 10,000 feet. Cultivated. Introduced 1881.

59. **R. triternatus** GRAY, Proc. Am. Acad. **21**: 370. 1886.

Roots fascicled, fleshy-fibrous: plant low: leaves often 3-times 3-divided and parted; leaflets long-petioled, their lobes narrow-linear to linear-spatulate and obtuse: petals yellow, 4 to 5 lines long, obovate: akenes turgid, not margined; beaks slender: receptacles thick: head of fruit globose. Near Goldendale, S. Wash.

60. **R. Grayi** BRITTON, Bull. Torr. Club, **18**: 265. 1891.
R. pedatifidus HOOK. Fl. **1**: 18. *t. 18.* 1829. Not Smith.
R. Hookeri REGEL, Bull. Soc. Nat. Mosc. **34**: 2: 47. 1861. Not Schlecht.
R. Drummondi GREENE, Erythea, **2**: 192. 1894.

Rather stout, 1–2-flowered: basal leaves either biternately or pedately divided and parted into linear oblong or spatulate lobes, main divisions often stalked: stem leaves similar, only 1 or 2: petals 3 lines long; sepals shorter, sparsely and finely villous: akenes each about 1 line long, borne in a globular head. Lat. 52° to 55°, on eastern Rockies, Gray's Peak, Colo., and near Ironton, 12,000 to 13,000 feet.

61. **R. pygmæus** Wahl. Fl. Lapp. 157. *t. 8. f. 1.* 1812.
R. Lapponicus Oed. Fl. Dan. *t. 144.* 1762. Not Linn.

Very minute, 1 or 2 inches high, puberulent or glabrous: leaves 3–5-lobed or divided, 2 to 5 lines wide, lower ones on slender petioles, others subsessile: flowers 2 to 3 lines across; petals yellow, little longer than the sepals: akenes lenticular; beak slender: head of fruit somewhat oblong, 2 lines long. High Rockies of Montana to Colorado, polar regions across America, Greenland, Europe and Asia.

Var. **Sabinii** n. var.
R. Sabinii R. Br. Parry 1st Voy. App. 264. 1824.
Flowers larger than the type: sepals hairy. Montana.

62. **R. oxynotus** Gray, Proc. Am. Acad. **10**: 68. 1874.

Caudex short, roots fibrous: plant glabrous, 4 to 10 inches high: radical leaves in a numerous tuft, 6 to 10 lines across, mostly round-reniform, with several roundish lobes or deep crenations: stem leaves 1 or 2, flabelliform to cuneate, 3–5-cleft or parted; lobes lanceolate-linear to oblong: petals yellow, broadly obovate, 4 to 5 lines long, exceeding the sepals: akenes compressed, semiovate, glabrous, about 1 line long; beak strong, subulate: head of fruit 6 lines long: receptacle thick and fleshy. Mineral King Mt., Mariposa Co., and central Sierras, all in California.

63. **R. digitatus** Hook. Kew Journ. **3**: 124. *t. 4.* 1851.

Very low, glabrous: roots a cluster of slender tubers: stem leaves few, subsessile, 2–4-parted; lobes oblong-lanceolate to nearly linear; radical leaves similar or entire and lanceolate, petiolate: petals 5 to 11, yellow, spatulate-oblong, 3 to 5 lines long: akenes slightly compressed and margined; styles slender: head very small, often elongated. Yellowstone Park to northern Nevada.

64. **R. glaberrimus** Hook. Fl. **1**: 12. *t. 5.* 1829.
R. brevicaulis Hook. Lond. Journ. Bot. 6: 66. 1847.
R. Austinæ Greene, Erythea, **3**: 44. 1895.

Root a cluster of thickened fibers: plant rather succulent, 4 to 10 inches high, glabrous: radical leaves roundish to oblanceolate or spatulate; base tapering or obtuse, often 2–5-lobed above, or crenate or entire; stem leaves usually deeply 3-lobed or parted, lobes entire: petals yellow, broadly obovate, 3 to 6 lines long; sepals nearly as long, often purple beneath: akenes puberulent or glabrous, lenticulate, slightly margined, with small, short beak: fruit in a globose to oblong head. Early spring. British Columbia to California and Colorado.

Var. **ellipticus** GREENE, Fl. Francis, 298. 1892.

R. ellipticus GREENE, Pitt. **2**: 110. 1890. **3**: 92. 1896.

Basal leaves elliptic-lanceolate to oblong, entire or only once lobed on one side: petals often much narrower than in the type: head of akenes drooping to the ground. Distributed with the type in its lower altitudes and southern range.

65. **R. Macauleyi** GRAY, Proc. Am. Acad. **15**: 45. 1880.

R. nivalis REP. Chief Eng. U. S. A. **1878**: 1833. Not Linn.

Some of the roots thick and fleshy: plant 3 to 7 inches high; stem villous-hairy to glabrous, young leaves very villous on margins: leaves thick, lanceolate to ovate-spatulate, entire except toward the apex, there often coarsely or finely 2 to 10 toothed; lower leaves petiolate, others sessile or on short, sheathing petioles: petals obovate to flabelliform, crenulate, 5 to 7 lines long, yellow; sepals shorter, densely coated beneath with dark brown hairs; peduncles hairy: akenes smooth, somewhat compressed, slightly margined; styles linear-subulate, persistent, nearly straight: head of fruit ovate to oblong or cylindric. Near snow line, 11,500 feet altitude in La Plata mountains and San Juan Co., Colo.

66. **R. nivalis** LINN. Sp. Pl. 553. 1753.

R. sulphureus SOLAND. in Phipp's Voy. 202. 1774.

A short caudex with slender roots: plant pubescent or becoming glabrous below, 3 to 7 inches high: lower leaves cuneate-flabelliform to reniform, about 3-lobed or deeply cleft; lobes sometimes notched; upper leaves subsessile, about 5-lobed or parted, divisions linear-oblong, entire: petals yellow, obovate to roundish, sometimes emarginate, 3 to 4 lines long; sepals shorter, densely wooly: akenes rather turgid; beak subulate. Greenland, Hudson Bay region, Alaska, Hall island, Behring Sea, south in Rockies to Lat. 55°, Northern Asia and Europe.

67. **R. natans** C. A. MEYER ex Ledeb. Ic. *t. 114*. 1830.

R. radicans C. A. MEYER ex Ledeb. Ic. *t. 116*. 1830.

R. Purshii TORR. Ann. Lyc. N. Y. **2**: 162. 1828. Not Richards.

R. hyperboreus var. *natans* REGEL, Bull. Soc. Nat. Mosc. **34**: pt. 2: 43. 1861.

Much like *R. hyperboreus*, but differing in having leaves larger, reniform or truncate at base, lobes 3 to 5, often more rounded: petals much larger; receptacle thickened and fleshy: head of fruit larger. Creeping and rooting in mud or sometimes floating in shallow water. Rockies of Colorado. Also northern Asia.

68. **R. hyperboreus** ROTTB. Skrift. Kjoeb. Selsk. **10**: 458. *t. 4. f. 16.* 1770.

Low creeping plant with slender and glabrous stems and petioles: one or two leaves from each (rooting) node, broadly ovate with rounded or truncate bases, 3-lobed or slightly cleft, margins of lobes nearly entire; petioles sheathing at the base: flowers minute, few, yellow; petals about equalling the reflexed sepals; peduncles 1 inch or less in length: akenes hardly compressed; beak almost wanting: head of fruit globose, hardly 2 lines broad. Wet soil. Greenland, Labrador, Arctic Alaska; also Europe and Asia.

69. **R. Lapponicus** LINN. Sp. Pl. 553. 1753.
Anemone nudicaulis GRAY, in Bot. Gaz. **11**: 17. 1886.

Scapose from filiform rootstocks, 3 to 6 inches high: radical leaves long-petioled, 3-parted, the divisions obovate-cuneate, obtuse, crenate or lobed: scape slender, taller than the leaves, often with a lobed, bract-like leaf: flower solitary, yellow; petals 5 to 6; sepals of about the same length, reflexed: akenes a line or more long, ovate, tapering into the persistent, hooked beak. North shore of Lake Superior, west to the Rockies, north to Arctic America; also Europe and Siberia.

70. **R. delphinifolius** TORR. ex Eaton, Man. 2 ed. 395. 1818.
R. multifidus PURSH, Fl. **2**: 736. 1814. Not Forsk.
R. flaviatilis BIGEL. Fl. Bost. 1 ed. **1**: 39. 1814. Not Willd.
R. lacustris BECK & TRACY, N. Y. Med. & Phys. Journ. **2**: 112. 1823.
R. Beckii G. DON, Gen. Syst. **1**: 39. 1831.
R. Purshii var. *aquatilis* LEDEB. Fl. Ross. **1**: 35. 1841.
R. multifidus var. *terrestris* GRAY, Man. 5 ed. 41. 1867.

Aquatic or partly emersed, with long fistulous stems: submersed leaves ternately decompound into narrow filiform or capillary divisions, flaccid, petioles very short and sheathing; emersed leaves smaller, and much less dissected, often only 3–7-parted into cuneate lobes, petioles often longer than blades; young leaves from nodes taking root on muddy banks, still less lobed and divided, their petioles and under sides hairy: petals deep yellow, 5 to 8, broadly obovate, 4 to 6 lines long, exceeding the sepals: akenes rather turgid, obliquely ovate, hardly 1 line long, becoming callous-margined on base and ventral edge; beak half their length, straight, compressed: head of fruit globose or oblong. Quiet water, and muddy ditches and banks. North Carolina to northern Canada, west to British Columbia and California. Also Siberia.

71. **R. Purshii** RICHARDS, Frankl. 1st Journ. 741. 1823.

R. pusillus LEDEB. Mem. Acad. Petrop. **5**: 546. 1812.
R. Gmelini DC. Syst. **1**: 303. 1818.
R. Langsdorfii DC. Prod. **1**: 34. 1824.
R. limosus NUTT. ex Torr. & Gray, Fl. **1**: 20. 1838.
R. radicans REGEL, Bull. Soc. Nat. Mosc. **34**: pt. 2: 44–5. 1861. Not Mey.
R. multifidus var. *limosus* LAWSON, Rev. Canad. Ranunc. 47. 1870.
R. multifidus var. *repens* WATS. Bot. King Exp. 8. 1871.

Stems slender, rooting at lower nodes and creeping, in muddy places, pubescent on younger parts: leaves slender-petioled, 3 to 12 lines broad, palmately divided into obtuse lobes and segments: petals yellow or whitish, 1 to 3 lines long, ovate; sepals smaller, falling early: akenes smooth, ½ line long, no calloused margin; style persistent, slender, shorter than the body: head of fruit smaller than in *R. delphinifolius*. Bogs, ditches, etc. Arctic America to Northern Michigan, west to British Columbia and Washington, south to New Mexico.

72. **R. Missouriensis** GREENE, Erythea, **3**: 20. 1895.

Much like *R. Purshii* in habit and leaves: differs in being sparingly pubescent: leaves wider than long, 1 to 3 inches wide: head of fruit more oblong: akenes prominently callous-margined up one edge, sides wrinkled; style subulate, ½ as long as body. Missouri to New Mexico.

73. **R. aconitifolius** LINN. Sp. Pl. 551. 1753.

Plant pubescent, ½ to 3 feet high, branched: leaves palmately 3–5-parted, parts cut-toothed, upper ones sessile and with oblong to linear-lanceolate lobes: flowers white, several on a stem; sepals flat, pubescent; petals oblong, cuneate to orbicular. May to June. Mountains of middle Europe. Var. *flore-pleno* HORT., called White Bachelor's Button, and Fair Maids of France, has very ornamental, double, white, globose flowers. Garden 45, p. 29 and 48, p. 506. Var. *luteus-pleno* HORT., flowers much doubled but of a golden yellow color. The type and varieties are used in borders and half wild places.

74. **R. Pallasii** SCHLECHT. Animad. Ranunc. 1: 15. *t. 2.* 1819.

Plant creeping, glabrous: stems and petioles large, hollow; ascending part of stem naked or 1-leaved: leaf-blades short, linear to oblong, rather obtuse, entire or sometimes 2–3-lobed: petals 8 to 11, oblong to obovate, white, 4 to 6 lines long; sepals 3 to 4, shorter, greenish, broad: akenes thin-crustaceous, 2 lines long; beak short. In shallow water. Arctic Alaska, St. Lawrence islands, etc., across to northern Asia, and Lapland.

75. **R. amplexicaulis** LINN. Sp. Pl. 549. 1753.

Stems erect, 5 to 10 inches high, with two or three flowering branches, glabrous: leaves entire, ovate to lanceolate, amplexicaul, acuminate, glabrous or at first with hairy edges soon becoming glabrous, glaucous: flowers 3 to 6, either terminal or axillary, pure white with yellow stamens; sepals pointed; petals much larger, obtuse. Mountains of southeastern Europe. The plant is well suited to garden use and does not intrude upon other plants. It does not do well in the dryest places. The cut flowers preserve their freshness well. Bot. Mag. 266 (poor). Bot. Cab. 1593. Journ. Hort. III, 35, p. 345. Gard. Chron. 1883, 19: 788.

76. **R. Lambertianus** D. DIETR. Syn. Pl. 3: 316. 1843.

Plant swimming: leaves lanceolate, entire or subdenticulate, their long petioles sheathing the stem at their base: flowers small, yellow, axillary or terminal; petals obtuse, longer than the stamens and sepals. Wet places. Mexico. *R. natans* NEES, ex G. Don, Gen. Syst. 1: 31, 1831 (not C. A. Meyer), is probably a form of this with leaves sometimes bifid. Mexico.

77. **R. arnoglossus** GREENE, Pitt. 4: 143. 1900.

Plant tufted, about 6 inches high: leaves feather-veined, elliptic and elliptic-lanceolate, entire; petioles of all shorter than the blade, sheathing at base: flowers many, large; petals 5, obovate, obtuse, commonly persistent with the sepals: akenes many: head dense, globose. Subalpine in the Ruby mountains of eastern Nevada.

78. **R. unguiculatus** GREENE, Pitt. 4: 142. 1900.

Stem 1 foot or more high, solitary: radical leaves 1 or 2 only, erect, elliptical, or obovate-elliptic, acute, entire or obscurely denticulate, 2 to 3 inches long; petioles as long; stem leaves narrower, short-petioled: flowers 2 to 4, or more in the large plants; peduncles long, puberulent, naked; petals about 10, persistent, narrow, claw ½ line long; sepals narrow, spreading, deciduous: akenes glabrous, obliquely obovoid, slightly compressed; beak stout, slightly recurved: head depressed globose. 11,500 feet. Southern Colorado. C. F. Baker, August 28, 1899.

79. **R. ambigens** WATS. Bibl. Index, 1: 16. 1878.

R. Flammula PURSH, Fl. 2: 391. 1814. Not Linn.

R. Lingua PURSH, l. c. Not Linn.

R. alismæfolius BENTH. Pl. Hartw. 295. 1848. In part. Not Geyer.

R. obtusiusculus BRITTON, Ill. Fl. 2: 76. 1895. Not Raf.

Plant 2 to 3 feet high, stout, glabrous or nearly so, erect, but sometimes rooting at the lower nodes, hollow: leaves usually on short petioles with broad, membranous, sheathing bases; blades lanceolate with tapering bases, serrate, denticulate or entire, 2 to 4 inches long: petals 5 to 7, yellow, 2 to 3 lines long; sepals shorter: akenes small, obliquely oval, compressed, thickened along one margin; beaks subulate, narrow, erect or little curved, nearly as long as akene body: head of fruit globose. Wet grass lands. Mountains of Georgia and Tennessee to Missouri, north and east to Canada and New England.

Var. **obtusiusculus** n. var.

R. obtusiusculus RAF. in Desv. Journ. Bot. 1: 225. 1808.

Differs from the type in its slender, straight, erect stem: its single root, like an annual, and its linear-lanceolate sepals.

80. **R. Madrensis** Rose, Cont. Nat. Herb. 5: 199. 1899.

Plant erect, rather slender, 6 to 12 inches high, glabrous on lower parts; 1–4-flowered; radical leaves 1 to 2 inches long, petioled, linear to linear-oblong, with coarse distant teeth, obtuse; base cuneate; stem leaves reduced to bracts, simple or 3-lobed: flowers yellow, on long slender peduncles which are hairy near the flower; receptacle hairy; petals about 10, obovate to oblong, 3 to 4 lines long: akenes hardly 1 line long, compressed, glabrous; beak as long, slender. Sierra Madre mountains, between Santa Gertrudis and Santa Teresa, Tepic Ty., and in Zacatecas. Altitude 7,400 to 10,000 feet.

81. **R. alismæfolius** Geyer, in Benth. Pl. Hartw. 295. 1848.

R. Flammula Hook. Lond. Journ. Bot. 6: 66. 1847.

R. Bolanderi Greene, Bull. Calif. Acad. Sci. 2: 58. 1886.

R. Hartwegi Greene, Erythea, 3: 45. 1895.

Roots fibrous, fascicled: plant erect, usually robust, 6 to 15 inches high, branching or nearly simple, slightly pubescent on peduncles: leaves oblong to lanceolate, tapering at base, entire or denticulate, 1 to 3 inches long; petioles short and broad, sheathing at base; upper stem leaves sessile: petals yellow, 6 to 10, obovate, 4 to 6 lines long; sepals much shorter, reflexed: akenes compressed, smooth; beak short, often hooked: head of fruit nearly globose. Wet grounds. British Columbia and Colorado to California.

Var. **Calthæflorus** n. var.

R. Calthæflorus Greene, Erythea, 3: 45. 1895.

Leaves repand-denticulate, and much broader than the type: flowers and petals not different. Colorado, in boggy ground, 8,000 feet.

82. **R. alismellus** Greene, Fl. Francis, 2: 97. 1892.

R. alismæfolius var. *alismellus* Gray, Proc. Am. Acad. 7: 327. 1868.

R. alismæfolius var. *montanus* Wats. Bot. King Exp. 7. 1871.

Much like *R. alismæfolius*, but usually very slender, dwarf, often nearly scapiform: leaves lanceolate-elliptical to ovate: petals smaller, 3 lines long. Plants often form a thick covering over the wet ground. High altitudes, Sierra and Trinity Mts., California to Colorado and northward.

Var. **Populago** n. var.

R. Populago GREENE, Erythea, **3**: 19. January, 1895.

R. Cusickii JONES, Proc. Calif. Acad. Sci., Ser. 2, **5**: 615. October; 1895.

Like the type, but with radical leaves ovate, cordate; margins slightly wavy. Southwestern Oregon, Idaho.

83. **R. Lemmoni** GRAY, Proc. Am. Acad. **10**: 68. 1874.

Stems scapose, tufted, 5 to 10 inches high: plant villous-pubescent on lower parts: leaves rather thick, lanceolate, entire: flowers 1 or 2 on a stem; petals about three lines long, obovate to oblong: akenes turgid, villous-pubescent, borne in an oval head. Rare. Truckee and east part of Sierras, California.

84. **R. oblongifolius** ELL. Sketch **2**: 58. 1824.

R. Flammula MICHX. Fl. **1**: 221. 1803. Not Linn.

R. Flammula var. *laxicaulis* TORR. & GRAY, Fl. **1**: 16. 1838.

R. pusillus var. *oblongifolius* TORR. & GRAY, l. c. 17.

R. laxicaulis DARBY, Bot. S. St. 204. 1855.

Annual; about 1 to 2 feet high, erect or ascending, rarely rooting at the lower nodes, branched above, many-flowered: leaves shaped nearly as in *R. pusillus*, or sometimes broader: petals 5, yellow, longer than the sepals; stamens many: akenes few, often globular or slightly flattened, smooth or minutely punctate; style deciduous: head of fruit globose. April to September. Wet grounds. Florida to southern Virginia, west to southern Missouri and Texas.

85. **R. hydrocharoides** GRAY, Mem. Am. Acad. **5**: 306. 1855.

Stems ascending, 5 to 10 inches high, rooting at the lower nodes, with creeping, fistulous branches at the base: leaves mostly long-petioled, entirely or nearly so, usually less than 1 inch long, rather succulent; basal leaves round-cordate to oval, blending into the form of the upper ones which are obovate to spatulate: petals 5 or more, 2 to 3 lines long; sepals much shorter: akenes small; beak narrow, short: head of fruit small, globose. In standing water and wet soil. Southwestern Arizona into adjacent California, and in Lower California, at La Chuparosa and Sierra de la Laguna. Flowers appearing very late at high altitudes.

86. **R. samolifolius** Greene, Pitt. 3: 13. 1896.

Much like *R. hydrocharoides.* Leaves entire, obtuse, oblanceolate, petioled; upper ones oval or obovoid: petals obovate; sepals round-ovoid, spreading: akenes like that species. High altitude, Mt. Shasta, southward.

87. **R. stolonifer** Hemsl. Diag. Pl. Nov. 17. 1879.

Plant small, entirely glabrous, spreading by stolons: stem erect, 2 to 6 inches or less: leaves subentire or sometimes crenate, the radical ones long-petioled, reniform or roundish elliptical to lanceolate-oblong; blade 3 to 12 lines long, petiole 1 to 2, with base membranous and dilated; stem leaves sessile, narrow: flowers small, yellow, long-peduncled; receptacle conical, glabrous; sepals oblong, 1 to 1½ lines long; petals 5 or 6, oblong-elliptical, about 1¼ lines long, the long claw with a conspicuous nectary; stamens longer than petals, filaments dilated: akenes much compressed, slightly margined, glabrous: head of fruit globose. Near Morales in San Luis Potosi, Mex., 6,000 to 8,000 feet altitude.

88. **R. vagans** Wats. Proc. Am. Acad. 26: 131. 1891.

Plant low, glabrous, spreading by elongated stolons: leaves narrowly lanceolate, or the lowest ovate-lanceolate, entire or with a few often slender teeth toward the apex: petals 8 to 10, oblong-obovate, about 2½ lines long, a prominent nectar pore above the narrow claw; sepals little over half as long: akenes smooth, in a dense globose head 2½ lines in diameter. Flor de Maria, State of Mexico. Aug., 1890. Pringle no. 3177.

89. **R. reptans** Linn. Sp. Pl. 549. 1753.

R. filiformis Michx. Fl. 1: 320. 1803.
R. reptans var. *filiformis* DC. Syst. 1: 248. 1818.
R. Flammula var. *filiformis* Hook. Fl. 1: 11. 1829.
R. Flammula var. *reptans* E. Meyer, Pl. Labr. 96. 1830.

Stem prostrate, rooting at the nodes, pubescent or nearly glabrous: leaves linear-lanceolate to spatulate, usually entire, 1 to 2 inches long, narrowed into the petiole: peduncles ascending, 1 to 3 inches, each terminated by a single flower; petals

4 to 7, bright yellow, 2 to 3 lines long, exceeding the sepals; stamens many: akenes flattened somewhat; beak minute, sharp. Coast of Arctic America, Newfoundland; near ponds and lakes, New Jersey to California: Greenland, Europe, Asia.

Var. **Gormani** n. var.

R. Gormani GREENE, Pitt. **3**: 91. 1896.

Like the type, but with leaves broadly ovate or deltoid-ovate, acute, few-toothed, 6 to 8 lines long. Near Crater lake, southern Oregon.

90. **R. Unalaschensis** BESS. ex Ledeb. Fl. Ross. **1**: 32. 1841.

R. Flammula var. *intermedius* HOOK. Fl. **1**: 11. 1829.

R. reptans var. *intermedius* TORR. & GRAY, Fl. **1**: 16. 1838.

R. Flammula var. *Unalaschensis* LEDEB. ex Regel, Bull. Soc. Nat. Mosc. **34**: pt. 2: 41. 1861.

R. reptans var. *strigulosus* FREYN, Deutsch. Bot. Monats. 8: 181. 1891.

R. intermedius HELLER, Bull. Torr. Club, **25**: 280. 1898. Not Poir. nor Eaton.

This differs from *R. reptans* in its more robust habit, longer peduncles, leaves larger, sometimes being 3 to 5 inches long and 2 to 6 lines wide. Newfoundland past the Great Lakes to Oregon and California, northward. Europe. Asia.

91. **R. microlonchus** GREENE, Erythea, **4**: 122. 1896.

Allied to *R. reptans*, often more hairy; stem slender, somewhat ascending, 1–few-flowered: radical leaves in a tuft, shaped as in that species or a little broader; stem leaves few, short petioled to subsessile: flowers 4 lines broad; petals 5 to 8, obtuse; sepals spreading: akenes as in that species but with a short, stout, blunt beak: head of fruit depressed-globose. Northern Idaho.

92. **R. trachyspermus** ENGELM. ex Gray Pl. Lindh. **1**: 3. 1850.

R. trachyspermus var. *angustifolius* ENGELM. l. c.

Annual: plant glabrous, ½ to 2 feet high, sometimes rooting at the lower nodes: leaves slender-petioled, oblong to linear lanceolate, entire or denticulate, bases often tapering; petioles of stem leaves expanded near the bases: peduncles rather short;

petals 1 to 3 or 5, pale yellow, about 1 line long; stamens only 5 to 10: akenes oblong, hardly compressed, slightly margined; beak very short: head of fruit oblong. Low, wet places, Dallas, Tex., south and southeast.

93. **R. pusillus** POIR. in Lam. Encycl. **6**: 99. 1804.
R. Flammula WALT. Car. 159. 1788. Not Linn.
R. Bonariensis POIR. in Lam. Encycl. **6**: 102. 1804.
R. humilis PERS. Syn. **2**: 102. 1807.

Annual: plant ½ to 2 feet high, slender, weak, branching, glabrous: basal and lower stem-leaves mostly ovate, petiolate; others nearly sessile, linear or lanceolate; all entire or minutely toothed: petals yellow, few, barely exceeding the sepals; stamens 1 to 10: akenes obovate, tipped with the base of the style: head of fruit globose. Marshy ground, New York, New Jersey, to Florida, through Gulf region to Texas and Missouri.

Var. **Lindheimeri** GRAY, Proc. Am. Acad. **21**: 367. 1886.
R. trachyspermus var. *Lindheimeri* ENGELM. ex Gray Pl. Lindh. **1**: 3. 1850.
R. Biolettii GREENE, Pitt. **2**: 225. 1892.

Low, rarely a foot high: akenes more papillose-roughened than in the type. Middle coast of California to Galveston, Tex., and New Orleans.

94. **R. Andersoni** GRAY, Proc. Am. Acad. **7**: 327. 1868.
Oxygraphis Andersoni FREYN, Flora, **70**: 140. 1887.

About 6 to 8 inches high, stem one-leaved or a naked scape: basal leaves rather thick, 2 to 3 times ternately or pedately divided or parted, lobes linear to lanceolate: flowers 1 or 2; sepals glabrous; petals ½ inch long, pink or rose, orbicular, obovate or flabellate, claws narrow: akenes compressed, but wholly utricular with membranous walls, oblique obovate to orbicular, ¼ inch long, a very narrow membranous margin; apex abruptly sharpened with a very short style. Boise City, Idaho, Salt lake, Utah, to eastern Sierras of California and Nevada.

95. **R. juniperinus** JONES, Proc. Cal. Acad. Sci., Ser. 2, **5**: 616. 1895.
R. Andersoni var. *tenellus* WATS. Bot. King Exp. 7. *t. 1, f. 8–10.* 1871.

Plant taller and more slender than *R. Andersoni;* usually branched once, 1-leaved and 2-flowered: radical leaves more finely dissected than in that species: petals white or rose-purple without: akenes flat, not inflated, very small, only 1 to 1½ lines long. Rocky places in woods of Utah.

96. **R. glacialis** LINN. Sp. Pl. 553. 1753.

Roots fibrous: plant low: lower leaves petioled, others sessile and involucrate, all 3-parted or trifid and again lobed; upper ones often villous: flowers 1 to 3, white or reddish; petals obovate to cuneate, blunt; sepals shorter, very densely hairy. Summer. Mountains of Europe, Arctic regions, Greenland. Garden 45, p. 28; 48 p. 501.

KUMLIENIA GREENE, Bull. Calif. Acad. **1**: 337. 1886.

(Named for the late botanist, Prof. Kumlien of Wisconsin.)

Low perennials; stem nearly leafless, 1–2-flowered: leaves mostly radical, rounded and lobed: sepals 5 to 7, white, conspicuous; petals 5, small, oval, fleshy, with nectariferous pit and slender claw; stamens and pistils many: akenes lanceolate, acuminate, compressed, membranaceous, and utricular, obscurely 1-nerved on the sides; style hooked, persistent; seed much shorter than the cell. A monotypic genus of narrow distribution. Of it Greene remarks that it has the general aspect of *Ranunculus;* flowers of *Caltha*, with nectary-like petals of *Helleborus*, the utricular fruit peculiar. This is section PSEUDAPHIANTOSTEMMA of Gray, under *Ranunculus*.

K. histricula GREENE, l. c.

Ranunculus hystriculus GRAY, Proc. Am. Acad. **7**: 328. 1868.

Stems 4 to 10 inches high, bearing 1 or 2 3-lobed leaves: radical leaves round-reniform, with 5 broad rounded lobes; petioles long: flowers 1 or 2: akenes 3 lines long including the style. April to June. Portland, Ore., east to the Sierra Nevadas. Rare.

FICARIA HUDS. Fl. Angl. 213. 1762.

(Latin for fig, referring to the thickened roots.)

Perennial herbs with tuberous roots; plants all glabrous; stems branched or simple: leaves petioled, entire or toothed, cordate: flowers large, solitary, either axillary or terminal; sepals 3 to 5, deciduous; petals about 8 (7 to 12), yellow, or red at the base; carpels numerous, blunt, not wrinkled nor ribbed, cotyledon only 1: akenes borne in a head. A genus of only about three species natives of Europe and Asia. The following one is naturalized here:

F. ranunculoides MOENCH, Meth. 215. 1794.

Ranunculus Ficaria LINN. Sp. Pl. 550. 1753.
F. verna HUDS. Fl. Angl. 1 ed, 214. 1762.
F. polypetala GILID. Fl. Lituan. **2**: 259. 1781.
F. Ficaria KARST. Deutsch. Fl. 565. 1880–83. (Not binomial.)
F. communis DUM.-COURS. Bot. Cult. 2 ed .**4**: 445. 1811.
F. calthæfolia REICHB. Fl. Germ. Excurs. 718. 1830–32.
F. grandiflora ROBERT, Cat. Toulon, **57**: 112. 1838.
F. Roberti F. SCHULTZ, Arch. Fl. 346. 1848.
F. ambigua BOR. Fl. Cent. Fr. 3 ed. **2**: 20. 1857.
F. nudicaulis KERN. in Oestr. Bot. Zeitschr. **13**: 188. 1863.
F. intermedia SCHUR. Enum. Pl. Transs. 14. 1866.
F. transsilvanica SCHUR. l. c. 14.
F. aperata SCHUR. in Verh. Naturf. Ver. Bruenn. **15**: 231. 1877.
F. Holubyi SCHUR. l. c. 32.
F. rotundifolia SCHUR. l. c. 32.

Stem scape-like, or 1–2-leaved, about 5 inches high: leaves ovate cordate, obtuse, crenate, 1 to 2 inches long; petioles broad: flowers yellow; petals 8 or 9; sepals 3: head of fruit globose: akenes beakless, truncate. Run wild on Long island; Staten island; Hingham, Mass.; Richmond Co., N. Y., and near Philadelphia. Regne Vegetale **9**: 6.

CYRTORHYNCHA NUTT. ex Torr. & Gray, Fl. **1**: 26. 1838.

(From the Greek, meaning curved-beak.)

Slender, erect, perennial herbs, with fibrous roots: leaves lobed: flowers small, yellow; sepals 5, spreading deciduous; petals 5, narrowly spatulate or oblong, pit at base, small; stamens many: akenes terete, longitudinally ribbed; style incurved. A monotypic genus. Section CYRTORHYNCHA Gray, under *Ranunculus*.

C. ranunculina NUTT. l. c.
Ranunculus Nuttallii GRAY, Proc. Acad. Phil. 56. 1863.
R. ranunculinus RYDBERG, Bot. Surv. Neb. **3**: 23. 1894.

Glabrous, 6 to 10 inches high : leaves usually narrowly lobed; basal ones long-petioled ; stem leaves few, beneath the branches : flowers several, somewhat corymbose : akenes tipped with the persistent, slender, recurved style. Spring and Summer. Nebraska to Wyoming. *C. neglecta*, in Greene's herbarium, is a form with roots more succulent; stems and leaves like the above; petals perhaps a little larger.

ARCTERANTHIS GREENE, Pittonia, **3**: 190. 1897.

(Combination of *Arctic* and *Eranthis:* in allusion to its habitat and resemblance to *Eranthis*, or *Cammarum*).

A monotypic genus of perennial herbs : roots rather fascicled or clustered on a short caudex : leaves mostly radical, rounded and lobed: flowers solitary; sepals 5; petals 10; stamens many : akenes in a head, longitudinally ribbed, beaks reflexed. Part of Section CYRTORHYNCHA Gray, Syn. Fl. **1**: 23, under RANUNCULUS.

A. Cooleyæ GREENE, l. c. 190. *pl. 3*.
Ranunculus Cooleyæ VASEY & ROSE, Contr. Natl. Herb. **1**: 289, pl. 22. 1893.
Kumlienia Cooleyæ GREENE, Erythea, **2**: 193. 1894.

Plant glabrous, 3 to 8 inches high: scape 1–2-flowered, sometimes bearing a small leaf near the middle, extending above the leaves when in fruit; basal leaves many, orbicular, one inch or more across, deeply 3-parted, and again lobed and toothed, glandular tips to the teeth; petioles broadened or sheathing at the base : flowers yellow; sepals oblong, obtuse, deciduous; petals oblong, obtuse, tapering into a slender claw at base : carpels compressed laterally, 1–3-nerved on each side; reflexed style short; ovule erect. August. Mountain tops near Juneau, and St. Elias Alps, Alaska.

OXYGRAPHIS BUNGE Verz. Suppl. Fl. Alt. 46. 1836.

(From Greek, meaning sharp-style.)

Trailing and running perennial herbs, with fibrous roots : leaves crenate-dentate or lobed, long-petioled, glabrous : flowers small, yellow, one to several on scape-like stems; sepals often 5, deciduous; petals 5–12, pit at base small; stamens many: akenes compressed, somewhat swollen, thin-walled, striate with simple or branched nerves: head of fruit oblong or oval. Several species, but the following only is found in America.—Section HALODES, Gray, Proc. Am. Acad. **21**: 366, under *Ranunculus*.

O. Cymbalaria PRANTL, in Engl. & Prantl, Nat. Pfl. Fam. 3: Abt. 2, 63. 1891.

?*Ranunculus saluginosus* PALL. Reise. **3**: 263. 1776.

R. Cymbalaria PURSH, Fl. **2**: 392. 1814.

R. halophilus SCHLECHT. Animad. Ranunc. **1**: 23. *t. 4. f. 1.* 1819.

R. tridentatus H.B.K. Nov. Gen. & Sp. Pl. **5**: 42. 1821.

R. Cymbalaria var. *alpinus* HOOK. Fl. **1**: 11. 1833.

Cyrtorhyncha Cymbalaria BRITTON, Mem. Torr. Club, **5**: 161. 1894.

Leaves orbicular to ovate, cordate or truncate at base, one inch long or even much less: scapes short; receptacle elongating in fruit: akenes minutely sharp-pointed. Summer. Shady shores and moist saline or salt grounds. Arctic sea coasts to New Jersey, west to Minnesota, thence south and west. Also Mexico, South America, Greenland, Asia.

INDEX TO NAMES OF RANUNCULUS.

(References to other genera are indicated by their initials.)

XXVII. A SYNONYMIC CONSPECTUS OF THE NATIVE AND GARDEN THALICTRUMS OF NORTH AMERICA.

K. C. Davis.

The name *Thalictrum* (Linn. Sp. Pl. 545. 1753) is probably from *Thallo*, to grow green, and has reference to the young shoots which are of such a bright green color.

This group includes several forms which are well suited for the mixed border and rock garden, and the robust forms are well placed in the wild garden. Many are very hardy, and only the more southern forms of those given below are at all tender. *Thalictrums* are valued for their healthy heads of flowers, contrasted with their handsome stems and leaves which are often of a purple cast. They may be propagated by seed or by division of roots in early spring just as growth begins. Any good loamy soil will suit them if well drained.

The latest monograph of the genus was in 1885, by LeCoyer, in Bull. Soc. Roy. de Bot. de Belge, where he describes 69 species. In 1886 Wm. Trelease published a fine treatment of "North American species of *Thalictrum*" in Proc. Bost. Soc. Nat. Hist. **23**: 293–304, in which he recognized eleven species and four varieties north of Mexico. His treatment is rather closely followed by Robinson in Gray's Synop. Fl. 1895. Since that time at least ten new species have been described—chiefly from Mexico—several of which are by J. N. Rose in Contr. U. S. Natl. Herb. **5**: 185, October 31, 1899. Only five have been introduced to our gardens from other countries.

Erect perennial herbs: leaves ternately compound and decompound; stem leaves alternate: flowers diœcious, polygamous, or perfect in some species, rather small, generally greenish-white or sometimes purple or yellow, borne in a panicle or loose raceme; sepals 4 or 5, deciduous; petals wanting; stamens many, showy; carpels usually few, 1-seeded.

KEY TO SPECIES OF THALICTRUM.

A. Natives of United States or introduced.
  B. Flowers perfect.
    C. Filaments widened above; anthers ovate, obtuse.
      D. Akenes sessile, in a head, ovate oblong........*petaloideum*.
      DD. Akenes stalked, widely spreading, straight along dorsal margin.
        E. Styles very short; stigma almost sessile........*clavatum*.
        EE. Styles as long as width of akene...........*sparciflorum*.
    CC. Filaments filiform; anthers linear, acute, or mucronate.
      D. Stigma hastate or spurred; flower-stem abruptly recurved near the fruit..*alpinum*.
      DD. Stigma not spurred nor hastate.
        E. Fruits sulcate; stigma dilated on one side of the short style........ ....*minus*.
        EE. Fruits longitudinally veined; stigma terminal, minute, not dilated, style short...............................*glaucum*.
  BB. Flowers polygamo-diœcious.
    C. Anthers linear, mucronate; filaments thread-like. *purpurascens*.
    CC. Anthers ovate, obtuse; filaments broadened above. *polygamum*.
  BBB. Flowers diœcious, with rare exceptions.
    C. Filaments widened above; anthers ovate, rather obtuse. *aquilegifolium*.
    CC. Filaments thread-like; anthers linear, acute or mucronate.
      D. Mature fruits rather firm or thick-walled, not greatly flattened, filled by the seed; leaves glabrous.
        E. Blades of leaflets very thin.
          F. Roots tuberous; stem reclining.....................*debile*.
          FF. Roots coarsely fibrous; stem erect............*dioicum*.
        EE. Blades of leaflets firm, veiny below.
          F. Styles clubbed............................*Caulophylloides*.
          FF. Styles not clubbed.
            G. Akenes well stalked..........................*coriaceum*.
            GG. Akenes nearly sessile......................*venulosum*.
      DD. Mature fruits less firm, thin-walled, 2-edged, either flattened or turgid.
        E. Leaflets very thin..................................*occidentale*.
        EE. Leaflets firm.
          F. Pistils 5–11 (rarely 13) ....*Fendleri*.
          FF. Pistils 7–20.................................*polycarpum*.
AA. Natives of Mexico, not introduced into United States.
  B. Leaflets peltate or subpeltate.

C. Akenes at least twice as long as broad.
  D. Plant glaucous throughout; akenes narrowly elliptical, tapering at base or stalked.
    E. Divisions of leaves large, crenations broad and shallow. *peltatum.*
    EE. Divisions of leaves small, with small ovate teeth. *Jaliscanum.*
  DD. Plant not at all glaucous; akenes subsessile, one side straight .... *Cuernavacanum.*
CC. Akenes a little longer than broad.
  D. Leaves once or twice ternate; leaflets large, orbicular. *Pringlei.*
  DD. Leaves 4 or 5 times ternate; leaflets small, ovate. *Guatemalense.*
BB. Leaflets subpeltate on only part of the plant........*pubigerum.*
BBB. Leaflets not peltate nor subpeltate.
C. Flowers perfect.
  D. Plant pubescent .... *longistylum.*
  DD. Plant glabrous.......................... ....*Pachucense.*
CC. Flowers monœcious or polygamous (*T. papillosum* doubtful).
  D. Plant glabrous or only glandular, very little or no pubescence.
    E. Akenes ribbed, not gibbous.
      F. Leaves 4–5 times ternate; leaflets 1 to 2 inches across. *grandiflorum.*
      FF. Leaves 2–3 times pinnate; leaflets small and thin. *Galeottii.*
    EE. Akenes with convex protuberances on the ribs.
      F. Anthers mucronate..........................*Hernandezii.*
      FF. Anthers linear, but rather blunt..............*gibbosum.*
  DD. Plant pubescent, hispid or hairy.
    E. Fruits not woolly.
      F. Leaflets glabrous above, glandular-hispid beneath. *lanatum.*
      FF. Leaflets papillose above; hairy veins prominent beneath ....*papillosum.*
    EE. Fruits woolly...................................*tomentellum.*
CCC. Flowers diœcious.
  D. Leaves pinnately compound.........................*pinnatum.*
  DD. Leaves ternately compound.
    E. Styles wanting.......................................*Madrense.*
    EE. Styles filiform, 3–4 lines long............*grandifolium.*

T. petaloideum LINN. Sp. Pl. 2 ed. 771. 1762.

Stem round, nearly 1 ft. high, almost naked: leaves 3–5-parted; leaflets smooth, ovate, entire, or 3-lobed: flowers corymbose, perfect; sepals white, rotund; filaments pink, anthers yellow: fruits ovate-oblong, striated, sessile. June–July. Northern Asia. Bot. Cab. 9: 891. Not yet in trade lists but well worthy of use in gardens (†). Lec. 3. *f. 15.*

T. clavatum DC. Syst. 1: 171. 1818.
T. filipes TORR. & GRAY, Fl. 1: 38. 1838.
T. nudicaule SCHWEINITZ ex T. & G. Fl. 1: 39. 1838.

Plant glabrous, 1 to 2 feet high, branching above: leaves 2 to 3 times ternate: leaflets oval to obovate, rather large, thin, about 3-lobed but variable, base variable: flowers perfect, in a cymose panicle; filaments spatulate and petal-like, with short, blunt anthers: akenes widely spreading on weak stalks of nearly their own length, obliquely ovoid, flattened; styles short; stigma minute. May, June. Wet mountain places, western Virginia to Alabama (†). Lec. 3. *f. 10.*

T. sparciflorum TURCZ. F. & M. Ind. Sem. Petrop. 1: 40. 1835.
T. clavatum HOOK. Fl. 1: 2. 1833, not DC.
T. Richardsonii GRAY, Am. Journ. Sci. 42: 17. 1842.

Stem erect, sulcate, 2 to 4 feet high, branching, usually glabrous: leaves triternate, upper ones sessile; leaflets short-stalked, round or ovate, variable in size and shape of base, round-lobed or toothed: flowers in leafy panicles on slender pedicels, perfect; sepals obovate, whitish, soon reflexed; filaments somewhat widened; anthers very short: akenes short-stalked, obliquely obovate, flattened, dorsal margin straight; 8–10-nerved; styles persistent. Northern Asia, through Alaska to Hudson Bay, in mountains in Colorado and southern California. Introduced to gardens in 1881. Lec. 3. *f. 8.*

T. alpinum LINN. Sp. Pl. 545. 1753.

Stems smooth, naked or 1-leaved, only 4 to 8 inches high, from a scaly rootstock: leaves tufted at the base, twice 3–5-parted; leaflets coriaceous, orbicular or cuneate at the base, lobed, revolute: flowers in a raceme, perfect; sepals greenish, equalling the yellow stamens: stigma linear; akenes small, obliquely obovoid. Newfoundland to Arctic Alaska, in Rockies to southern Colorado, Europe, northern Asia, Greenland and Iceland. Bot. Mag. 2237. Lec. 4. *f. 13* (†).

T. minus LINN. Sp. Pl. 546. 1753.
T. saxatile VILL. Prosp. 50. 1779.
T. purpureum SCHANG. in Pall. N. Nord. Beitr. 6: 42. 1794.
T. saxatilis HORT.

Stems round, sulcate, 1 to 2 feet high: leaflets variable, acute or obtusely lobed, often glaucous: flowers drooping in loose panicles, perfect; sepals yellow or greenish: fruit ovate-oblong, sessile, striated. Summer. Europe, Asia, northern Africa. A polymorphous species in the variation of the leaflets. Lec. 5. *f. 2, 3, 4.*

Var. **adiantifolium** HORT.
T. adriantoides HORT.
T. adiantifolium BESS. ex Eichw. Skizze 182. 1830.
Leaflets resembling those of *Adiantum;* a form much used and admired.

Var. **Kemense** TRELEASE, l. c. 300. 1886.
T. Kemense FRIES, Fl. Holland, 94. 1817–18.
T. minus var. *elatum* LEC. l. c. 283. 1885. In part.
Leaves thrice-ternate; otherwise much like the type.

T. glaucum DESF. Thal. 1 ed. 123. 1804.
T. speciosum HORT. ex POIR. Encycl. **5**: 315. 1804.

Stems erect, round, striated, glaucous, 2 to 5 feet high: leaflets ovate-orbicular, 3-lobed, lobes deeply toothed: flowers in an erect panicle, perfect; sepals and stamens yellow: fruits 4 to 6, ovate, striated, sessile. June, July. Southern Europe. Lec. 5, *f. 8.*

T. purpurascens LINN. Sp. Pl. 546. 1753.
T. rugosum PURSH. Fl. **2**: 389. 1814.
T. revolutum DC. Syst. **1**: 173. 1818.
T. Cornuti var. *a* HOOK. Fl. **1**: 3. *t. 2.* 1833.
T. dasycarpum FISCH. & LALL. Ind. Sem. Hort. Petrop. 72. 1841.
T. purpureum HORT.

A polymorphous species, allied to *T. polygamum:* stem 3 to 6 feet high, branching above, leafy, pubescent or glabrous, sometimes glandular; leaflets larger than in that type: flowers in a long, loose, leafy panicle, polygamo-diœcious; filaments narrow, anthers rather long, taper pointed: akenes slightly stalked, ovoid, glabrous or pubescent with 6 to 8 longitudinal wings; style slender, persistent; stigma long and narrow, Canada to Florida, west to the Rockies. June, Aug. Introduced 1883.

Var. **ceriferum** Austin, Gray Man. 5 ed. 39. 1867.

T. revolutum Lec. l. c. 146. *t. 3, f. 1.*

This is a variety with waxy glands.

T. polygamum Muhl. Cat. 54. 1813.

T. corynellum DC. Syst. 1: 172. 1818.

T. Cornuti var β Hook. l. c. 3.

T. Cornuti Torr. & Gray, Fl. 1: 38. 1838.

T. leucostemon Koch. & Bauché, Ind. Sem. Hort. Berol. App. 13. 1854.

Erect, 3 to 8 or more ft. high, branching and leafy, smooth or pubescent, not glandular: leaves 3–4 times ternate or terminally pinnate; leaflets oblong to orbicular, bases variable, 3–5 apical lobes: flowers in a long, leafy panicle, polygamo-dioecious; sepals white; filaments broadened when young; anthers short: akenes ovoid, stipitate, 6–8-winged or ribbed; with stigmas as long, which become curled. July–August. Low or wet grounds, Canada to Florida, west to Ohio. Introduced 1881. Lec. 2. *f. 12.* *T. pubescens* Pursh, Fl. 2: 388, 1814, is probably a very pubescent form of this and might be called var. *pubescens.*

Var. **macrostylum** Robinson, Syn. Fl. 1: 17. 1895.

T. Cornuti var. *macrostylum* Shuttle. in Dist. Pl. Rugel, 1845–6.

T. Cornuti var. *monostyla* Bot. Zeit. 3: 218, 219. 1845.

T. macrostylum Small & Heller, Mem. Torr. Club, 3: 8. 1892.

Slender; leaflets small, nearly entire: fertile flowers less numerous and in a more spreading panicle: akenes in a small, dense, spherical head. Mountains of western North Carolina to Georgia.

T. aquilegifolium Linn. Sp. Pl. 547. 1753.

Stem large, hollow, 1 to 3 feet high, glaucous: leaves once or twice 3–5-parted; leaflets stalked or the lateral ones nearly sessile, slightly lobed or obtusely toothed, smooth, suborbicular:

flowers in a corymbose panicle, diœcious; sepals white; stamens purple or white: fruit 3-angled, winged at the angles. May–July. Europe, northern Asia. Bot. Mag. 1818; 2025 (as var. *formosum*). Garden 47, p. 357; 50, p. 117. Lec. 3. *f. 5.*

The old name, *T. Cornuti* L. Sp. Pl. 545, may be a synonym of this, and, if so, it is the older name being published on a preceding page; but *T. Cornuti* was described as an American plant which *T. aquilegifolium* is not. As the description and old figures of *T. Cornuti* L. do not agree with any American plant the name may well be dropped, as Robinson and DeCandolle have suggested. Those plants advertised as *T. Cornuti* are probably *T. aquilegifolium.*

T. debile Buckley, Am. Journ. Sci. **45**: 175. 1843.

Root a cluster of fusiform tubers: stem decumbent, ½ to 1 foot long, glabrous, simple or branched, few-leaved: leaves 2 to 3 times ternate; petioles long and slender; leaflets nearly ½ inch across, thin, rotund, the 3 rounded lobes entire or again lobed, bases variable: flowers remote, in long, simple panicles, diœcious; stamens often 10, filaments little longer than the anthers: akenes 2–5, nearly sessile, spreading, oblong, not flattened, 8–10-ribbed; style minute. Moist or shady places. Georgia to Texas. Lec. 2. *f. 1* (†).

Var. **Texanum** Gray, Cat. Coll. Hall, Pl. Tex. 3. 1873. Name only.

Stems more rigid and erect; leaflets smaller, thicker and nearly sessile. A Texas form of the above (†). Described in Syn. Fl. **1**: 18. 1895.

T. dioicum Linn. Sp. Pl. 545. 1753.
T. lævigatum Michx. Fl. **1**: 322. 1803.
T. Carolinianum Bosc. in DC. Syst. **1**: 174. 1818.

Rather slender, 1 to 2 feet high, glabrous: leaves 3 to 4 times 3-parted; leaflets thin, orbicular, several-lobed or revolute, bases variable: flowers in a loose, leafy panicle with slender pedicels, diœcious; stamens much longer than the greenish sepals; anthers linear, obtuse, exceeding their filaments in length: akenes ovoid, nearly or quite sessile, longer than their styles, with about 10 longitudinal grooves. Early spring. Woods. Labrador to Alabama, west to the foot of the Rockies. Introduced sometime before 1891. Lec. 3. *f. 2, 3.*

T. Caulophylloides SMALL, Bull. Torr. Club, **25**: 136. 1898.

Plant glabrous, 2 to 4 feet high, from a horizontal rootstock; leaves on long petioles; leaflets deep green, firm, oval or broader than long, 1 to 2 inches long, glaucous beneath and with prominent nerves, bases variable, apically 3–5-sharp-lobed; flowers diœcious: akenes elliptic, 3 lines long, sharply ribbed, contracted at the base and stalked, style persistent, clubbed, ½ the length of akenes. Spring and summer. Mountains of Tennessee.—Allied to *T. coriaceum*, but differing in the leaflets and the shorter club-shaped style (†).

T. Coriaceum SMALL, Mem. Torr. Club, **4**: 98. 1893.
T. dioicum var. *coriaceum* BRITTON, Bull. Torr. Club, **18**: 363. 1891.

Stem sulcate, somewhat branched, raising 3 to 4 feet from the yellow rootstocks: leaves 3 to 4 times ternate, rather short-petioled, lower petioles with stipule-like bases; leaflets coriaceous, broadly obovate, acutely toothed or lobed; bases variable; veins prominent on the whitish under surface: flowers in a loose panicle, diœcious; sepals and stamens whitish; anthers linear, longer than the slender filaments: pistillate flowers purple; akenes stalked, oblong-ovoid, 8–10-ribbed; styles of less length, persistent. May–June. Mountains of eastern Kentucky into Virginia and north Carolina (†).

T. venulosum TRELEASE, *l. c.*, 302. 1886.
T. campestre GREENE, Erythea, **4**: 123. 1893.
(?) *T. Fendleri* J. M. MACOUN, Bot. Gaz. **16**: 285. 1893.

Allied to *T. dioicum*: stem simple, erect, 10–20 inches high, glabrous, glaucous; bearing 2 to 3 long-petioled leaves above the base; leaves 3 to 4 times 3-parted; leaflets short-stalked, rather firm, rounded and lobed at the apex, veiny beneath: flowers in a simple panicle, diœcious, small; sepals ovate; stamens 10–20 on slender filaments; anthers oblong, slender pointed: akenes nearly sessile, 2 lines long, ovoid, tapering to a straight beak, thick-walled and 2-edged. South Dakota, westward and southward in the mountains. Introduced 1889.

T. occidentale GRAY, Proc. Am. Acad. **8**: 372. 1872.
T. dioicum var. *oxycarpum* TORR. Bot. Wilkes Exped. 212. 1854.

Allied to *T. dioicum* which it closely resembles; but it is more robust, taller: leaves glandular-puberulent: akenes long, slender, thin-walled, 2-edged, ribbed, not furrowed. Introduced 1881.

T. Fendleri ENGLEM. ex Gray in Mem. Am. Acad. **4**: 5. 1849.

A variable species: plants 1 to 3 feet high, rather stout and leafy: leaves 4 to 5 times pinnatifid, upper stem leaves sessile; leaflets rather firm, ovate to orbicular, usually with many shallow rounded or acuminate lobes, bases variable: flowers diœcious, in rather compact panicles; stamens many, anthers long: akenes nearly sessile, obliquely ovate, flattened, 3 to 4 ribs on each face. July–Aug. Western Texas to Montana. Introduced 1881. Lec. 2. *f. 9.*

Var. **Wrightii** TRELEASE, l. c. 304. 1886.

T. Wrightii GRAY Pl. Wright **2**: 7. 1852.

The upper leaves petioled; leaflets smaller, puberulent below: akenes plump, sigmoid, reticulated. Aug.–Sept. Dry regions. New Mexico, southern Arizona into Chihuahua. Lec. 2. *f. 8.*

Var. **platycarpum** TRELEASE, l. c. 304. 1886.

T. platycarpum GREENE, Pitt. **1**: 166. 1888.

T. hesperium GREENE, Pitt. **2**: 24. 1889.

Inflorescence sparsely glandular-puberulent: leaflets like the type: akenes flat, erect, dilated, the veins mostly longitudinal. Central and southern California.

T. polycarpum WATSON, Proc. Am. Acad. **14**: 288. 1879.

T. Fendleri var. *polycarpum* TORR. Pac. R. Rep. 4: 61. 1853.

T. Fendleri BREW. & WATS. Bot. Calif. **1**: 4. 1876. In part.

T. cæsium GREENE, Fl. Francis, 309. 1892.

Allied to *T. Fendleri*: glabrous throughout: leaflets long-petioled: flowers diœcious in rather close panicles: akenes larger in a dense globose head, stalked, obovoid, turgid tapering into reflexed styles. Summer. Sandy streams, California to Columbia river. Introduced 1881. Lec. 3. *f. 4.*

T. peltatum DC. Prod. **1**: 11. 1824.

Plant tall, glabrous or glaucous: upper stem leaves twice ternate: leaflets pale, 3 inches across, orbicular, mostly peltate, apically lobed or crenate: flowers polygamous in an open panicle: akenes flattened, obliquely oblong, being nearly straight on edge, base tapering but sessile, both faces 2–3-veined; styles ⅓ inch long, rather persistent. August. Morelos, south of Mexico City. Rose, l. c. 186, redescribes and figures this, plate 21. He concludes that DeCandolle's type may have been found in the same region. Type in U. S. Nat. Herb. 7448, distributed as *T. Pringlei* (†).

T. Jaliscanum Rose, l. c. 187. 1899.

Stems tall, glabrous and glaucous; upper leaves ternate, the leaflets peltate, orbicular, 6 to 10 toothed, glabrous: inflorescence a large open panicle: carpels narrowly elliptical, somewhat cuneate at base, strongly nerved. Quoted from Rose by whom it was first collected on tableland in northeastern Jalisco. Differs from *T. peltatum* in its small leaflets with small rounded teeth (†).

T. Cuernavacanum Rose, l. c. 187. 1899.

About 2 feet high, branching above, somewhat pubescent, never glaucous: leaves twice ternate; leaflets roundish, 1 inch across, palmate, broadly crenate: inflorescence an open panicle; flowers perfect; anthers linear; akenes 2 lines long, narrowed at both ends, subsessile, one side straight, 3–4-ribbed; styles long. Morelos, south of Mexico City (†).

T. Pringlei Wats. Proc. Am. Acad. 25: 141. 1890.
T. pubigerum Pringle, ex Rose, l. c. 187. 1899.

About 2 feet high, glabrous: leaves 1 to 2 times ternate; leaflets usually peltate, suborbicular, ½ to 2 inches across, coarsely 5–9-toothed, not glandular: inflorescence an open panicle, with slender nodding pedicels; flower polygamo-diœcious: anthers linear, long apiculate: akenes compressed, semi-ovate, straight on one side, 6–8-ribbed, 2 lines long; styles long, somewhat persistent. June–August. Near the capital of Jalisco, and the coast slope of the same state (†).

Var **reticulatum** Rose, l. c. 188. 1899.

A lower, somewhat pubescent form: leaflets peltate, entire or 3–5-angled, dark green above, strongly net-veined: flowers in a narrow panicle; peduncles nodding in fruit. Western foothills of Tepic Territory (†). The type 3372 in U. S. Natl. Herb. is a form of the same variety with the leaflets shallow-round-lobed, and some of them only subpeltate.

T. Guatemalense ROSE & C. DC., Contr. Natl. Herb. **5**: 188. 1899.

Stems about 2 feet high; slender, branched, somewhat hairy: leaves 4 to 5 times ternate; leaflets small, ovate, peltate, somewhat roughened, strongly veined below: akenes turgid, hardly 2 lines long. Guatemala (†).

T. pubigerum BENTH. Pl. Hartw. 285. 1839–57.

Plant rather tall, nearly simple, glabrous or pubescent, finely striated; leaves 2 to 4 times pinnate; leaflets distant, their stalks stipuled, often ovate, sometimes subpeltate, cordate or roundish at base; summit 3-toothed, often with other smaller teeth: flowers monœcious or polygamous, reddish; anthers linear, mucronate: akenes stipitate, glabrous, flattened, obliquely ovate, reticulately veined, protuberiferous, reflexed; style withering. Summer. West central Vera Cruz (†).

T. longistylum DC. Syst. **1**: 171. 1818.

Plant tall, sparsely pubescent even to the fruits: leaflets roundly lobed and toothed outwardly, pubescent beneath: flowers perfect, anthers slender, pointed: fruits flattened a little, reticulately ribbed, straight along one side; styles slender, longer than the body before becoming broken. August. Moist banks, Sierra de las Cruces, Mexico, 10,000 feet. Also South America (†).

T. Pachucense ROSE, l. c. 188. 1899.

Delicate glabrous plant, 8 to 12 inches high; roots fibrous: leaves only 3 to 4 inches long, mostly basal, 3 times ternate; leaflets 2 to 4 lines long, broad or narrow, bases variable: flowers perfect, on erect pedicels which become bent in fruit; sepals purplish; anthers narrow, apiculate: ovaries oblong; style long and slender. Open woods. High altitudes. Southern Hidalgo (†).

T. grandiflorum ROSE, l. c. 188. 1899.

T. grandifolium ROSE, l. c. 143. 1897. Not WATS.

Stems 5 to 8 feet high, glabrous: leaves 1 to 2 feet long, 4 to 5 times ternate; main petiole short with long dilating stipules: leaflets stalked, large, nearly orbicular, 1 to 2 inches across, often cordate at the base, 3 to 7 roundish lobes, sometimes a little hairy on under veins: flowers in a large, nearly naked panicle, polygamous ; filaments slender ; anthers linear : akenes flattened, strongly nerved, style persistent. Morelos, south of Mexico City (†).

T. Galeottii Lec. l. c. **24**: 131. *t. 2. f. 6.* 1885.

Rather tall and simple, glabrous, 2–3-pinnate; stipules ample; leaflets small, thin, ovate to obovate, toothed or lobed above, glabrous: panicles rather leafy; flowers small, whitish, monœcious or polygamous; sepals slightly dentate; anthers linear, somewhat obtuse: pistils 5 to 11: akenes nearly sessile, compressed, glabrous, semi-ovate, veined, widely spreading; styles long, slender, withering. September–October. Mountains of central Vera Cruz (†).

T. Hernandezii Tausch. in Presl. Reg. Haenk. **2**: 69. 1835.

Stem 3–5 feet high; glandulous, leafy, branching; leaves 2 to 3 times 5-parted; leaflets large, often subsessile, variable in outline, usually oval, 3-lobed or sharp toothed above; under side glandular: flowers in a conical panicle, monœcious or polygamous; sepals 4, greenish; anthers linear, mucronate: akenes 5–7, sessile or stipitate, obliquely ovate, compressed, spreading, irregularly ribbed and protuberiferous; styles long, slender, somewhat persistent. June–August. Southeastern Mexico, Oaxaca, etc. Lec. *2. f. 2* (†).

T. gibbosum Lec. l. c. **24**: 132. *t. 2. f. 7.* 1885.

Tall, erect, simple, or branched, glabrous: leaves 2 to 3 times pinnate, petiole stipuled; leaflets small, thin, oval, stalked, 3 sharp teeth above, often other small ones: panicles slightly leafy: flowers monœcious or polygamous, small, greenish; sepals feebly dentate; anthers linear, usually blunt; pistils 4–5: akenes stalked, flattened, tapering above and below, glabrous, strongly ribbed, reticulated and provided with protuberances, widely spreading; style long and slender, withering. Sept.–Oct. Mountains of western Oaxaca (†).

T. lanatum Lec. in Bull. Soc. Roy. Bot. Belg. **16**: 226. 1877.

Rather tall and leafy, hispid: leaves 2 to 3 times pinnate, very short petioled or sessile; leaflets variable in size and form, often orbicular or obovate, cordate or rounded at base, firm, glandular-hispid beneath, short-stalked, tridentate at summit, often with other smaller teeth: panicles many-flowered, monœcious or polygamous; sepals whitish; anthers linear, mucronate: akenes 5 to 7, sessile or nearly so, spreading, reticulately ribbed, glandulous; styles long and filiform, rather persistent. June–Aug. Oaxaca, southeastern Mexico (†). Closely allied to *T. Hernandezii*, but differing in being glandular hispid, and having no convex protuberances on the akenes.

T. papillosum ROSE, l. c. 189. 1899.

Low, hairy: leaves small, 3 times ternate; leaflets roundish, often cordate at base, somewhat 3-lobed, papillose above, hairy, veins prominent beneath: panicles short; pedicels becoming reflexed in fruit: akenes 1 line long, few-ribbed. Northern Jalisco and western Zacatecas (†). Fruit much shorter than in *T. lanatum*.

T. tomentellum ROBINSON & SEAT. Proc. Am. Acad. 28: 103. 1893.

Stem striate, glandular, finely and densely pubescent throughout: leaves 3 times pinnate on petioles 1 to 2 inches long; leaflets suborbicular, subcordate, shallowly 3-lobed; the lobes rounded, often with 2 to 3 rounded teeth: flowers in a pyramidal subnaked panicle, polygamo-diœcious; pedicels becoming reflexed in fruit: sepals 2 lines long; anthers setiform at tip: carpels about 10, scarcely stipulate, woolly, roughly reticulated, acuminate; style very long, filiform, often deciduous. July. About Lake Patzcuaro, Michoacan (†).

T. pinnatum WATS. Proc. Am. Acad. 23: 267. 1888.

Hardly 2 feet high, glabrous and glaucous, slender: root fascicled, tubero-fibrous: leaves lanceolate in outline, 2½ inches long or less, very shortly petioled, pinnate with about 7 (or fewer) pairs of divisions, the lower divisions ternate, with small lobed leaflets, the upper reduced to a single 3-lobed leaflet: flowers diœcious: sepals of the fertile flowers very small; stigmas short and rather thick: akenes ovate, about one line long, undulately ribbed, the oval seed filling the cavity. September. Pine plains, east base Sierra Madre, Chihuahua. Description from the original (†).

T. Madrense ROSE, l. c. 188. 1899.

Glabrous, slender, 1 foot or less high, from a cluster of thickened roots: leaves small, sessile, once or twice ternate: leaflets mostly 3-toothed or lobed: flowers diœcious (?); fertile flowers often axillary and single; styles wanting; stigma short and thickened: akenes with strong, undulate ribs. Quoted from Dr. Rose, who first collected it in southern Durango and northern Tepic (†).

T. grandifolium WATS. Proc. Am. Acad. **23**: 267. 1888.

Tall, usually glabrous: leaves 3 to 4 ternate, petiolate, with dilated stipules; leaflets 1 to 2½ inches long, obliquely rounded, often cordate, or upper ones cuneate at base, obtusely lobed, veins prominent beneath with a few scattered, short, stout, curved hairs: panicles spreading and somewhat leafy-bracteate; flowers nodding, diœcious: akenes semicircular, beaked by the short, stout base of the long filiform style (3 to 4 lines), compressed, faintly and irregularly nerved: seed flattened-subovate, filling the cavity. October. Under cliffs of Sierra Madre, Chihuahua (†).

T. Wrightii GRAY, occurs in both Mexico and New Mexico. It is placed in this arrangement as a variety of *T. Fendleri*, which see.

THALICTRUM INDEX.

alpinum L.
aquilegifolium L.
cæsium Greene = *polycarpum*.
campestre Greene = *venulosum*.
Carolinianum Bosc. = *dioicum*.
caulophylloides Small.
clavatum DC.
clavatum Hook. = *sparciflorum*.
coriacium Small.
Cornuti L., see *aquilegifolium*.
Cornuti var. *monostyla* Bot. Zeit. = *polygamum* var.
Cornuti var. *macrostylum* Shuttlew. = *polygamum* var.
Cornuti var. *α* Hook. = *purpurascens*.
Cornuti var. *β* Hook. = *polygamum*.
Cornuti T. & G. = *polygamum*.
corynellum DC. = *polygamum*.
Cuernavacanum Rose.
dasycarpum Fisch. &. Lall. = *purpurascens*.
debile Buckley.
debile var. *Texanum* Gray.
Delavayi Franc.
dioicum L.
dioicum var. *coriacium* Britton = *coriacium*.
Fendleri Engelm.
Fendleri var. *platycarpum* Trelease.
Fendleri Macoun. = *venulosum*.
Fendleri Brew. & Wats. = *polycarpum*.
Fendleri var. *Wrightii* Trelease.
Fendleri var. *polycarpum* Torr = *polycarpum*.
filipes T. & G. = *clavatum*.
Galeottii Lec.

NOTE.—The mark (†) indicates that the species or variety has not yet been introduced to the American trade. Citations after descriptions are mostly to pictures. "Lec." refers to LeCoyer's monograph.

XXVIII. SOME PRELIMINARY OBSERVATIONS ON DICTYOPHORA RAVENELII BURT.

C. S. Scofield.

The name *Dictyophora* was first applied by Desvaux in 1809 to a plant bearing a netted veil or indusium, and the genus so named was later included under the general family Phalloideæ, established by Fries in 1823. The family was given thorough systematic arrangement by Dr. Ed. Fischer * in 1888, and in 1896 Dr. E. A. Burt † published a systematic account of the ten known North American species under six genera.

The development of the sporophore has been especially studied in plants of this family, and this process has been described for many of the species. In the present paper less attention has been given to this particular feature of the life history, not that it is less interesting, but because in some of the stages it is not dissimilar to other species that have already been well described and figured.

Collection of material.—The material for the study of *Dictyophora ravenelii* was collected about September 25, 1899. It was found on low moist ground in rather dense woods near the west shore of Lake Calhoun, Minneapolis, Minnesota. The mycelium of the plant was more or less abundant over an area of five or six square yards, and the sporophores seemed to occur over most or all of this extent. The period of fruiting is evidently long, for photographs of the mature plants were made at least a month before the material was collected, and at the time of collection sporophores in nearly all stages of development were abundant.

Two collections of material were made: that of the first collection was put directly into thirty per cent. alcohol and afterward passed gradually into ninety per cent.; while that of the

* Saccardo, Syl. Fung. **7**: 1888.

† Bot. Gaz. **22**: 1896.

second collection was placed in a one per cent. solution of chromic acid, from which after twenty-four hours it was transferred to water and after thorough washing was carried by easy stages into seventy per cent. alcohol.

Methods.—The material for study was, with a few exceptions, dehydrated, imbedded in paraffin, and cut with a Minot microtome, carried down to fifty per cent. alcohol, stained in a fifty per cent. alcohol saturated solution of Bismarck brown, transferred into pure xylol and permanently mounted in Canada balsam. Some of the small portions of the mycelium and younger stages in the development of the sporophore were first stained *in toto*, and either mounted directly in formalin water and sealed or transferred to paraffin and cut and stained again if necessary. The pre-staining method proved very effectual and was of great help in guarding against the loss of very small bodies, and aided in the imbedding process. Numerous other staining methods were tried, but none gave as good result for structural study as the one outlined.

The vegetative tract consists of a complex weft of mycelial strands, which vary in size from something less than one-tenth of a millimeter in diameter up to two millimeters or more. The complexity of the weft is greatly augmented by the copious branching of the strands and not uncommonly crossing strands become more or less fused together. Some of the larger strands have a length of one meter or more, and often continue with unvarying diameter for forty or fifty centimeters.

The larger proportion of the mycelium is found near the surface of the soil where it is covered with leaf mould and may be found to some extent in the leaf mould itself. Some of it, however, runs to a considerable depth in the soil, but without diminishing in size or ending there as would a root of a higher plant. Invariably, strands found at the greatest depth of twenty to thirty centimeters could be traced to the surface in both directions. Branching seems to be less frequent on the strands found deep in the soil, and it was not possible to locate in any case what seemed to be the definite center of growth.

Each mycelial strand is composed of two general areas: the central and the peripheral. In the very small threads the central area (Fig. 9, *B*) consists of a few large hyphæ, very long in proportion to their diameters, aud without very definitely marked cross-septa. Their general direction is, of course, along the strand, but they are more or less twisted about each other, very much as are the threads which make up a strand of yarn.

The peripheral area (Fig. 9, *c*) is composed of loosely intertwining hyphæ, much smaller and more profusely branched than the central hyphæ, and extending out somewhat into the surrounding soil (Fig. 8). They seem to resemble very much the root hairs on the roots of higher plants. It seems quite probable that the hyphæ of the peripheral areas of the smaller strands function as the absorptive area of the plant, while the larger central hyphæ act as conduction paths.

In the larger strands the peripheral hyphæ occupy a relatively smaller part of the strand and seem to abandon their absorptive, to assume more of a cortical function, being reduced in the very large strands to a smooth disorganized coating. The central hyphæ by their habit of twisting about each other make it difficult to determine their method of growth and branching, for they do not continue long enough in the plane of the section to be studied with ease, and in no case were definite cross-septa noted although they doubtless exist.

Upon the mycelium are borne two distinct kinds of bodies: (1) the reproductive body, and (2) what it has seemed best to call a storage body or "tuber." The latter will be considered first.

The tuber makes its appearance as a slight enlargement of a mycelial strand, and in the early stages of its development seems to be merely the result of rapid growth of the peripheral hyphæ. There seems to be little regularity in the size or shape of the tubers and even less in regard to their place of occurrence upon the mycelium. In Fig. 10 one of the larger tubers is shown, natural size, and upon a connecting strand is shown at "*a*" the base of an old sporophore. The strand bearing this tuber seems to have been more or less branched and the tuber is lobed to some extent to follow the branching. The tuber is made up of very closely woven hyphæ which are much distorted, evidently by being packed full of somewhat granular material. In general structure it appears homogeneous except the region of the strand upon which it is borne, where the hyphæ seemed to leave the strand to some extent and mingle with those of the tuber, but not so much so that the direction of the strand cannot be clearly followed throughout. A section of a young tuber is diagrammatically shown in Fig. 11. The cell contents of the hyphæ of the tuber respond very neatly to a test for glycogen given by Dr. L. Errera,* and it seems very probable that this substance is a very large, if not the chief constituent of the cells. Errera's test is made with a reagent composed of 450 parts of water, three parts of KI and one part of iodine, and he designates it as "solution Iodée au $\frac{1}{450}$." According to him, material possessing glycogen when stained in this solution or when mounted in a drop of it takes on a reddish brown color, which disappears in a temperature of 50–60° C., but returns upon recooling. Some of the tests made on *Dictyophora* tubers were with material taken from 70 per cent. alcohol sectioned, transferred to water and mounted directly in a drop of the reagent.

In other instances sections that had been machine cut, stained in Bismarck brown, and mounted in Canada balsam were soaked in xylol to remove the cover glass and balsam, carried through alcohol to water, stained for a moment in Errera's mixture, and then mounted in water. In every case the reaction was sharp in all particulars.

Assuming that Errera's test is a correct one, and there appears no good reason for doubting it, it is evident that a large portion at least of the cell contents of the tuber is glycogen. Zopf, Burt † and others have associated the presence of glycogen in fungi with the immediate need of the plant for rapid growth, but there is at least a possibility that this reserve food supply in the tuber is in some way connected with the economy of the plant in reproducing itself vegetatively the following season. Or it may be that there exists a direct connection between the tuber and the rapidly developing sporophore, though there is no evidence that any of the supply of glycogen has been exhausted from any of the tubers collected or found upon the vegetative tract. If it is found upon further investigation that these tubers are connected with vegetative reproduction and that by means of them it is possible to artificially propagate the plant, it will be of great advantage in the study of the younger stages of development of the reproductive area. Hitherto the rare occurrence of the plant and its allies has made the study extremely difficult.

* Leo Errera, Sur le Glycogène ches les Basidiomycetes, 1885.

† Bot. Gaz. **24**: 1897.

The reproductive area usually occurs on a branch strand of the mycelium. The length of this branch varies with the distance of the main strand below the surface of the soil. In some instances this branch is so short that the sporophore seems sessile upon the main strand. Often the sporophore-bearing branch and the strand from which it comes are very small (Fig. 8), and the main strand here seems to diminish but little in size after giving off the branch. Both the branch and the strand, however, increase in size as the sporophore develops. In all cases the development of the sporophore takes place very close to the surface of the soil so that upon nearing maturity it pushes partially above the surface before the rupturing of the volva and the elongation of the stipe takes place. A number of these nearly mature sporophores are shown in an accompanying plate. Before taking up the development of the sporophore a brief description of the mature organ will be given to explain the parts and to define the terms used.

The mature sporophore (Fig. 7) is 8–10 cm. high and consists of a base *B*, volva V^1, V^2, V^3, stipe *S*, indusium *I*, pileus *P* and gleba *G*. The base may be considered for the present as a part of the volva, although structurally and developmentally it doubtless belongs to the same area as the stipe. The volva is slightly pinkish and consists of more or less definitely organized outer and inner layers with a disorganized milky-gelatinous layer between. The stipe is hollow, 2–3 cm. in diameter, dirty white, tapering at each end, with walls composed of several layers of chambers and passing with the pileus into a thick, white, recurved collar at the distal end. The border of the collar is entire, not convoluted as in some species.

The indusium or veil is membraneous and not of definite structure. It is attached at the point of union of the stipe and pileus and also to the volva near the base (Fig. 7, *i*). It ruptures irregularly upon the elongation of the stipe and may break from near either the point of attachment, or partially from both, and hang about the stipe as is shown in the first cut. Most commonly, however, it seems to break from near its attachment to the volva and hang between the pileus and stipe.

The pileus is conic-campanulate, 2.5–3.5 cm. long and 2–3 mm. thick, dirty white and with an entire, slightly recurved margin. It is composed of closely folded layers of pseudo-parenchymatous tissue, which give to its surface a finely wrinkled or granulate appearance.

The gleba is thin, slightly shorter than the pileus, very dark olive green and much firmer in texture and more persistent than is common with the other members of the genus; deliquescing slowly in dry weather and without so much of the fœtid odor common to the plants of this class.

The description of the development of sporophore must begin with the youngest stage found, although manifestly a complete description should start rather with the activity, nuclear or cytologic, that takes place before the spore-bearing branch is formed.

In the youngest stage found (Fig. 1), the sporophore was about .4 mm. in diameter and borne upon a branch about .1 mm. in diameter. The young sporophore consisted of but two distinguishable areas; the central (Fig. 1, *r*) and the peripheral (Fig. 1, *v*), the chief difference being that the hyphæ of the central area were somewhat larger and took a much deeper stain than those of the other. The two areas of the strand seemed to be continued into the sporophore with a slight increase in the proportional space occupied by the outer one. The line between them is not as clearly marked as in the strand, the hyphæ being closely anastomosed. A detail of the structure of this stage is shown in Fig. 12. Much time and ingenuity was spent in attempting to determine the condition in the strand just previous to the formation of the sporophore. It seems evident that one must look for the starting point in the main strand or at least in the very young branch.

There seems to be good reason for believing that some cell fusion may take place in the strand previous to the giving off of the sporophore branch. In Fig. 8 is shown a small mycelial strand with a branch "*a*" leading to a very small sporophore. Near the middle of this strand is shown one hypha much more prominent than the rest, so much so that it may readily be seen through the surrounding tissue, and by careful focusing its course may be traced for some distance either side of the place of branching. It is difficult to see through the tissue, and still more difficult to get sections to show whether or not an actual fusion has taken place, which has given rise to a new body. Evidently a fusion of some kind may have occurred, and, in the reaction following, one of the hyphæ may have come to be of a slightly different nature, for the single hypha is not particularly prominent except near the branching point. The uniform presence of this prominent hypha would suggest the idea that it is intimately concerned with the formation of the sporophore while also perhaps evidence that a fusion has taken place at this point may be seen in the knotted condition of the hypha. This gives rise to the thought that a cell fusion at this point may have initiated all the resulting activities. In Fig. 9 is shown a section of a small strand at the branching point and the supposed evidence of fusion is here very clear. That the peculiar deep-staining ability of this prominent hypha is consequent to such a fusion is indicated by the fact that the hypha cannot be traced along the strand any great distance from this point.

It is unfortunate that the technique of the material is not sufficiently developed to make possible a study of the nuclear phenomena at this point, for clearly the complete solution of this problem must lie in the study of the nuclear processes.

Whatever action takes place here is a matter of considerable importance in the life history of the plant, for the subsequent differentiation of the hyphal tissue is very complex.

The first marked step in the differentiation of the sporophore is shown in Fig. 2. The gelatinization of the area between the outer and inner layers of the volva is shown at V^2. There is a somewhat indefinite integument formed about the whole body by the breaking down of the hyphæ at the surface. The hyphæ lying in the area of the stipe *S* also begin to be prominent and tissue of much the same nature extends out like an umbrella from the top of the stipe area. This is evidently brought about by the apical growth of the large hyphæ shown in Fig. 1. Being limited by the denser hyphæ of the periphery, they take a downward direction. This tissue "*P*" gives rise later to the pileus and gleba and there remains between this and the stipe a tissue of the same structure as that of the volva. The tissue of the base "*B*" is similar in structure to that of the stipe, but closer in texture. The next important stage is shown in Fig. 3. Here the different areas are fairly well marked. The area between pileus and stipe is distinct, but is composed of very loosely woven hyphæ. It is in direct connection with the tissue of the volva, but is nearly separated from it by the base "*B*," which has extended considerably.

There becomes evident at this point an area of less tension near the middle of this base and just below the stipe. This is connected by a small pore, through the base, with the partially disorganized tissue in the center of the stipe. The stipe already shows very slightly its chambered structure and the areas of the pileus and gleba are distinguishable.

In Fig. 4 the relative size of the various parts is shown to be considerably modified. Gelatinization of the middle area of the volva is nearly complete. The indusium is almost entirely cut off from the volva and occupies a much smaller space than in the previous stage. The gleba is greatly enlarged, and the hymenial layer is beginning to show and the pressure of the whole receptaculum is beginning to be exerted upon the inner layer of the volva. The next stage as shown in Fig. 5 shows general enlargement of the parts and rapid development. Just how this enlargement takes place is not easy to understand. Certainly it is not altogether due to enlargement of existing hyphæ for excepting in the stipe and pileus actual measurement of the cells in the various stages show slight differences in the sizes of individual cells, so that enlargement must be very largely due to apical growth and branching.

The development as shown from Figs. 2 to 5 must go on very rapidly, for comparatively few sporophores in these stages were found. In Fig. 6 is shown the sporophore practically mature. The tissue in the middle of the stipe *X* is almost completely disorganized, showing the wall of the other side of the stipe in one or two places. The walls of the stipe are fully developed, but the cells of the walls of the chambers are closely compressed, especially at the angles. The indusium is reduced to a thin layer adhering closely to the sides. The inner layer of the volva is drawn very tightly over the gleba and is pressed against the outer layer at the tip. The gleba is completely developed and the spores are nearly or quite formed.

Fig. 7 shows the mature plant as previously described. The parts of it may now be described in detail. The base *B* is made up of small but entire hyphæ closely interwoven and shown in detailed structure in Fig. 19. The base forms a cup which loosely contains the base of the stipe to which it is attached only slightly, just about the pore which connects the hollow of the base with the hollow of the stipe. The tissue of the central area of the strand is in direct connection with the tissue of the base and the peripheral area of the strand at this time greatly reduced leads directly into the coating of the base and the outer layer of the volva.

The volva having been so tightly compressed before rupturing, has its two layers so close together that they might readily be mistaken for one, and the detailed structure is hard to recognize. The outer layer is hardened and the interstices between the hyphæ are filled with gummy material. The inner layer has its hyphæ lying for the most part in the direction of the recent strain and connects by a thin layer with the indusium.

The stipe is made up of several rows of irregular chambers as shown in Fig. 13 in cross section. Some of these chambers open to the outside, but none of them to the middle of the stipe. The chamber walls, one of which is shown in detail in Fig. 17, are made up of much distended hyphæ which look in section like the parenchymatous cells of higher plants. The chambers contain filmy remnants of disorganized tissue. The remnant of the tissue in the hollow of the stipe *X*, hangs usually from the apex of the stipe or some of it may remain attached at the base. The chambers of the stipe walls become smaller toward either end and at the apex the wall passes into the recurved collar where the contents of the chambers, though somewhat disorganized, are not absorbed.

The indusium which has been the cause of the trouble in classification is hardly to be considered the true indusium common to the genuine members of the genus *Dictyophora*. It is not a definitely organized structure, but rather the remnant of a portion of the tissues of the periphery of the young sporophore caught between the pileus and the base. Penzig* in describing *Ithyphallus tenuis*, speaks as follows: "Eine andere bemerkenswerthe Erscheinung bei *Ithypallus tenuis* ist das Auftreten einer Art von Indusium zwischen dem Hute und dem oberen Theile des Stieles. Auch Ed. Fischer (l. c., p. 22) kurz die Andesenheit einer Haut, welche er als 'Rest der stiel und Hute trennenden Primordialgewedes' auffast. Dieses Gedielde ist nicht in allen Individuen gleich ausgedildet: einmal nur als ausserest, feines, durchsichtiges Häutchen, andere Male aber als zienlich derbe, compacte membran, welche den Stiel kragenartig oder fast glockenförmig umgiebt. Ihere structur ist nicht pseudoparenchymatisch; vielmehr ist sie aus eng verflochtenen, cylindrischen Hyphen zusammengesetz."

Burt† in describing this plant writes: "This species has been

*Ann. Jard. Bot. de Buitenzorg, 2d Ser. Vol. I., part 2.

† Bot. Gaz. 22. 1896.

placed in the genus *Dictyophora* on account of its having a persistent membrane hanging about the angle between the pileus and the stipe. This membrane is composed of the same tissue, the intermediate tissue *A* of my figures; which gives rise to the veil in *D. duplicata*. Differentiation of this tissue does not advance in *D. ravenelii* to the final stage of making this membrane pseudoparenchyma, or is this final stage reached in the case of hyphæ composing the pileus in *I. impudicus* and in *D. duplicata*, yet no one would hesitate on that ground to use the term *pileus* in connection with those species. It seems best to apply the term *veil* to this membrane in *D. ravenelii* which looks like a veil, has the position of a veil, is composed of a tissue forming the veil in other species and is likely to be regarded as a veil without question by every botanist meeting this fungus for the first time and attempting its determination."

Burt's interpretation of this structure seems hardly the best one. The membrane as shown in detail in Fig. 15 bears no resemblance whatever to the tissue of the stipe and pileus shown in detail with the same enlargement in Figs. 14 and 16. The attachment of this membrane at the base of the volva and the fact that it ruptures irregularly, are both strong reasons for not considering it as a true veil or indusium. It would seem better to regard it rather as tissue which in other species of both *Ithyphallus* and *Dictyophora*, is completely disorganized—with the exception possibly of *I. tenuis*, mentioned by Penzig, where also a similar structure occurs. The presence of this tissue, although noted by the earlier writers, was not considered of importance enough to exclude the plant from the genus in which its other characteristics certainly placed it.

The pileus is composed of tissue very similar in structure to that of the stipe, except that the walls are closely folded and the tissue of the chambers is not so completely disorganized. The structure of one of the folds is shown in Fig. 14 while a longitudinal section showing the relative position of the walls is shown in Fig. 18. From a surface view the pileus has a finely wrinkled or granulated appearance. It is firmly attached to the apex of the stipe just below the collar. The line of demarkation between the pileus and the stipe at the point of attachment is not easy to make out. In fact at the point of union the tissue of the three areas, stipe, pileus and collar is homogeneous. It is close within the axis of the stipe and pileus that the so-called indusium is attached and often it clings so closely to the inner surface of the pileus as to be mistaken for a portion of that structure.

The gleba is much more persistent than in most forms of the family, maintaining itself for some hours after the elongation of the stipe. Its structure at this stage is very indefinite. Slight traces of the hymenium may be found, but for the most part it consists of a disorganized tissue containing masses of spores scattered about, held by the surrounding substance. The spores are very small, 1.5–2.5 mikrons in diameter, somewhat oblong and greenish black. In order to show the structure of the gleba the drawings for Figs. 16 and 17 were made from a young stage of the sporophore such as is shown in Fig. 6.

In conclusion the results of the study so far made upon this plant seem to suggest the following points:

1. The mycelium of the plant is of considerable structural importance and deserves further attention.

2. There are borne upon the mycelium certain organs which seem to function as storage places for reserve material.

3. There is in the young mycelial threads very good evidence of the occurrence of cell fusion previous to, or in intimate connection with the formation of the sporophore.

4. The indusium of this plant cannot be considered homologous with the indusium of true members of the genus *Dictyophora;* but is rather the persisting remnant of tissue which is completely broken down in most other plants of this order.

Explanation of Plates.

Plate XXIX.—Field view of undeveloped sporophores, from photograph by C. J. Hibbard.

Plate XXX.—Field view showing mature sporophore, from photograph by C. J. Hibbard.

Plate XXXI.—Structure and development of *I. ravenelii.*

1. A very young sporophore; *V*, volva; *R*, receptaculum. × 50.

2–7. Development of the sporophore; *B*, base; *V*, the outer layer of the volva; V^2, the middle layer of the volva; V^3, the inner layer of the volva; *I*, indusium; *S*, stipe; *P*, pileus; *G*, gleba; *C*, collar, and *X*, tissue remnant within the stipe.

8. Small mycelial strand with branch "a" leading to young sporophore. × 50.

9. Section of small strand at point of branching, showing large hypha at "a"; central area *B*; peripheral area *C*. × 100.

10. Tuber with connecting mycelium and base of an old sporophore at *A*. Natural size.

11. Section through a small tuber showing continuous mycelial strand. × 5.

12. Detail of portion of young sporophore shown in Fig. 1. × 500.

13. Diagrammatic view of section of stipe. × 5.

14. Detail of a fold of pileus tissue. × 500.

15. Detail of portion of indusium showing large drops of gelatine at hyphal ends. × 500.

16. Portions of hymenial layer in immature sporophore. × 500

17. Portion of wall of chamber of stipe. × 500.

18. Diagrammatic view of pileus and gleba immature. × 15.

19. Detail of portion of tissue of the base of the sporophore. × 500.

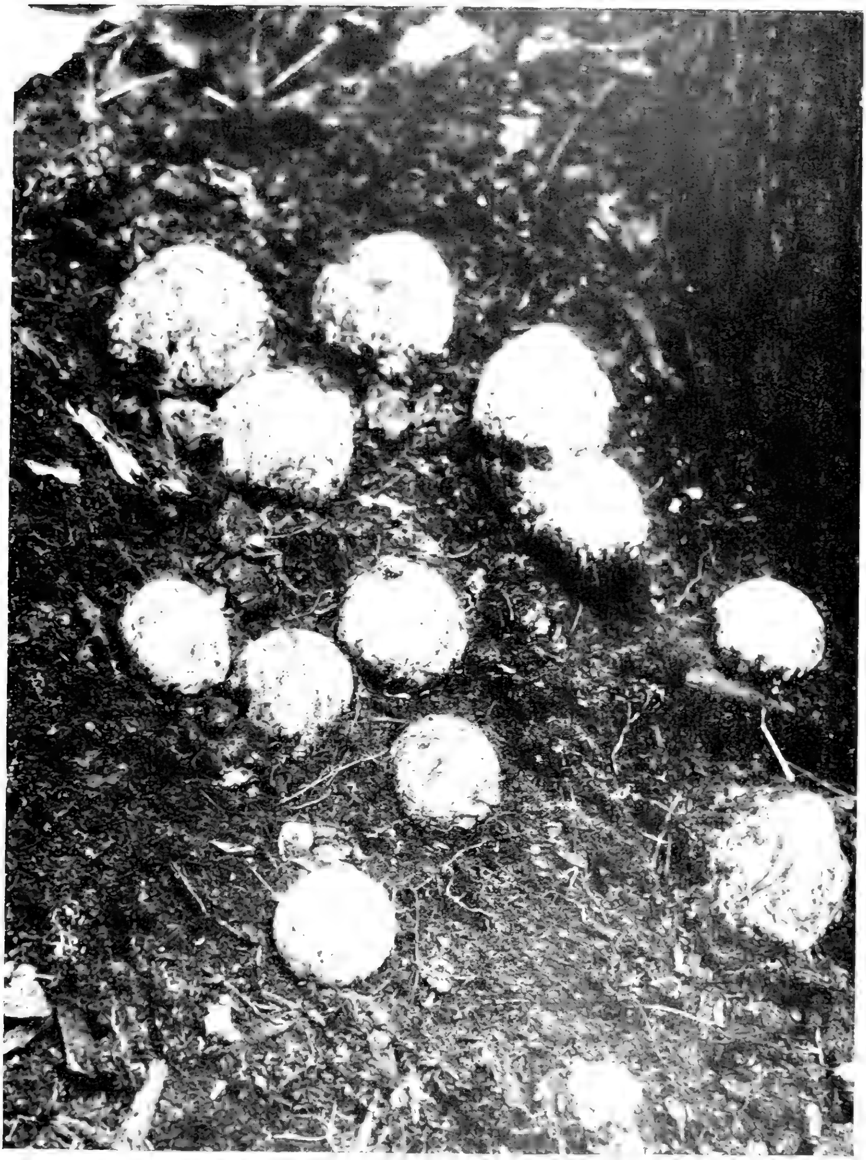
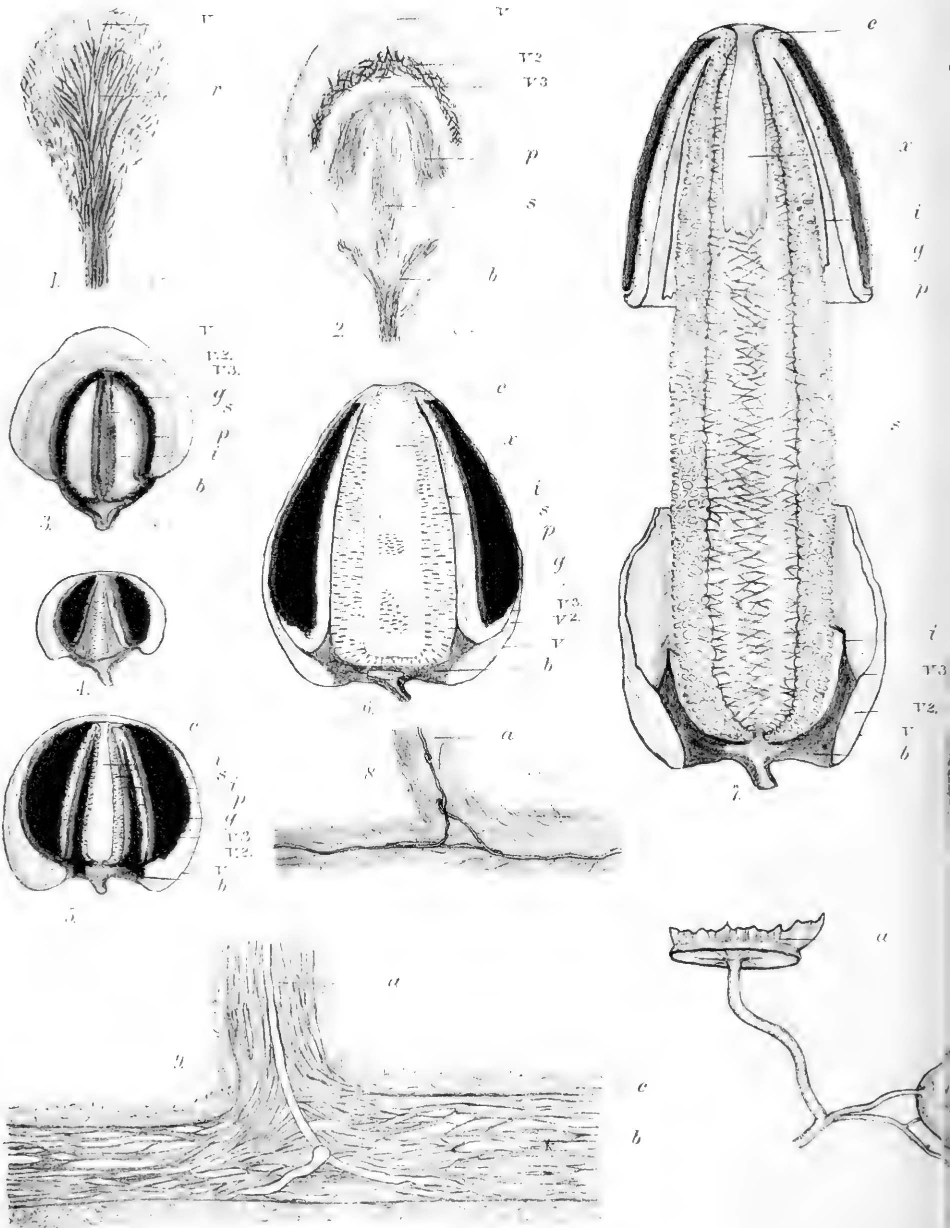
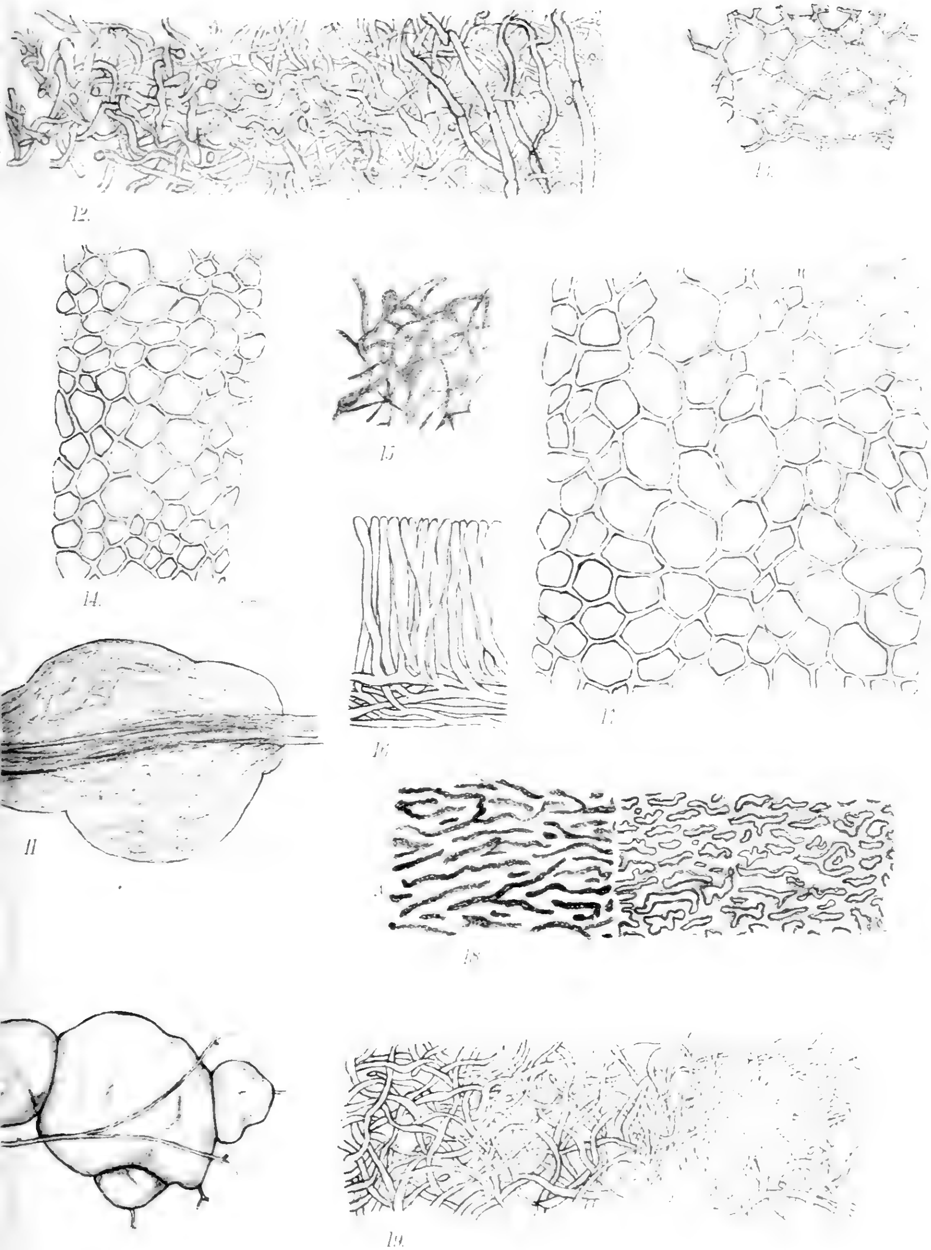


Plate XXIX

PLATE XXX

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XXIX. A PRELIMINARY LIST OF MINNESOTA UREDINEÆ.

E. M. Freeman.

The following list comprises the Uredineæ collected in Minnesota up to the present time, by the Botanical Survey Staff. The materials are taken from the collections cited in my preliminary list of Minnesota Erysipheæ.* In addition to these Dr. L. H. Pammel has made numerous collections at Hokah and other points in southeastern Minnesota. These have not been included in the present report but may be found in Trelease's Parasitic Fungi of Wisconsin.† *Puccinia anemones-virginianæ* is the only species collected by Dr. Pammel in Minnesota which has not been collected elsewhere in the State.

No representatives of the Endophyllaceæ or of the Schizosporaceæ have yet been found in Minnesota. Of the Melampsoraceæ five genera with seven species are reported, viz: *Chrysomyxa* 1 species, *Cronartium* 1, *Coleosporium* 1, *Melampsora* 3, *Calyptospora* 1; of the Pucciniaceæ seven genera with 62 species: *Uromyces* 14, *Puccinia* 39, *Gymnoconia* 1, *Uropyxis* 1, *Gymnosporangium* 4, *Phragmidium* 4, *Triphragmium* 1; of isolated *Æcidia* (including *Peridermia*) 30; of isolated *Uredo* 2.

On May 11, 1900, there was collected in Mille Lacs county a very large witches' broom on a white pine. The broom measures fully 9 feet across. The distortion of the branches is very pronounced and the leaves of the broom are considerably smaller than the normal. The cause of the formation cannot at present be positively ascertained. There are no indications that the branches contain an abundant mycelium and the material was collected early in the spring before æcidia had time to form. So far as I am aware no authentic record of a witches' broom upon pines caused by a fungus parasite exists.

* Minn. Bot. Stud. 2[4]: 417. 1900.

† Trans. Wisc. Acad. Sci. A. and L. 6: 1884.

In Sargent's Sylva* is a statement that pines are sometimes subject to the distortions known as witches' brooms. Dr. Farlow writes, however, that this statement was based on a reported witches' broom on *Pinus ponderosa* from Montana and that further study of the material demonstrated that the distortions were not typical witches' brooms, nor were they caused by a fungus parasite. No definite statement as to the cause of the broom of white pine collected in Minnesota can be made until older material is obtained and a more detailed description is therefore deferred.

DESCRIPTION OF PLATE XXXII.

Witches' broom on *Pinus strobus*, Mille Lacs county, Minn. After photograph by R. S. Mackintosh, May, 1900.

I. MELAMPSORACEÆ.

Chrysomyxa UNGER.

One species of this genus has been found. Common on *Pyrolas* throughout the State.

1. **C. pirolatum** (KOERN.) WINT. Die Pilze **1**[1]: 250. 1884.
On leaves of:
Pyrola rotundifolia L.: Goodhue, (II) Je. 1893, Ballard; Freeborn, (II) My. 1891, Sheldon 5964 and 5963.
Pyrola elliptica NUTT.: Aitken, (II) Je. 1892, Sheldon 2101; Houston, (II) Je. 1899, Lyon 98; Mille Lacs, (II) My. 1900, H. B. Carey and Freeman 560.
Pyrola secunda L.: St. Louis, (II) Jy. 1886, Holway 27. [*Uredo pyrolæ* (Gm.) Wint.]

Cronartium FRIES.

Not yet collected by the survey staff, but one species has been reported by Seymour.

1. **C. asclepiadeum** (WILLD.) FR. Obs. Myc. **1**: 220. 1815.
Var. **quercuum** B. & C.
Crow Wing, (III) Ag. 1884, Seymour. (Economic Fungi. A. B. Seymour and F. S. Earle, No. 215.)

Coleosporium LÉVEILLÉ.

One species found. Very abundant throughout the State. Uredospore form most abundant and conspicuous. Only one collection of the teleutospores has been made.

* Sylva of N. A. **11**: 12.

1. **C. sonchi-arvensis** (P.) WINT. Die Pilze I[1]: 247. 1884.
On leaves of:
Solidago serotina AIT.: Lincoln, (II) Ag. 1891, Sheldon 1506; Houston, (II) Ag. 1899, Lyon 360.
Solidago canadensis L.: Traverse, (II) S. 1893, Sheldon 7080.
Solidago flexicaulis L.: Case, (II) Ag. 1893, Anderson 702.
Solidago sp. indet.: Chicago, (II) S. 1891, Sheldon 4261; Lincoln, (II) Ag. 1891, Sheldon 1420; Hennepin, (II) O. 1898, Freeman; Traverse, (II) S. 1893, Sheldon 7308; Houston, (II) Ag. 1899, Lyon 430.
Laciniaria sp. indet.: Traverse, (II) S. 1893, Sheldon 7381.
Aster divaricatus L.: St. Louis, (II) Jy. 1886, Holway 102.
Aster macrophyllus L.: Cass, (III) Ag. 1893, Ballard 1747.
Aster sp. indet.: St. Louis, (II) Jy. 1886, Holway 165 and 251; Winona, (II) Jy. 1888, Holzinger 139; Houston, (II) Ag. 1899, Lyon 401 and 398; Hennepin, (II) S. 1889, MacMillan; Hennepin, (II) Ag. 1892, Sheldon 4122.
Doellingeria umbellata (DILL.) NEES: St. Louis, Jy. 1886, Holway 83.

Melampsora CASTAGNE.

Three species. The uredo forms of those species growing on *Populus* and *Salix* are especially abundant. All three species are Hemi-melampsoras.

1. **M. epilobii** (P.) FCKL. Sym. Myc. 44. 1869.
On leaves of:
Epilobium coloratum MUHL.: ——, (II) S. 1893, Sheldon 6147; St. Louis, (II) Jy. 1886, Holway 35 and 89.
Epilobium lineare MUHL.: St. Louis, (II) Jy. 1886, Holway 49.
Epilobium sp. indet.: Waseca, (II) Je. 1891, Sheldon 357.

2. **M. populina** (JACQ.) LEV. Ann. Sci. Nat. III. 8: 375. 1847.
On leaves of:
Populus tremuloides MICHX.: Otter Tail, (II) Ag. 1892, Sheldon 3890; St. Louis, (II) Jy. 1886, Holway 198

Populus deltoides MARSH.: Lincoln, (II) Ag. 1891, Sheldon 1573; Hennepin, (II) S. 1899, Lyon; Winona, (II). S. 1888, Holzinger; Hennepin, (II) S. 1889, MacMillan.

3. **M. salicis-capreæ** (P.) WINT. Die Pilze 1^2: 239. 1884.

On leaves of:

Salix discolor MUHL.: St. Louis, (II) Jy. 1886, Holway 101.

Salix myrtilloides L.: St. Louis, (II) Jy. 1886, Holway 166.

Salix sp. indet.: Hennepin, (II) S. 1890, MacMillan; Brown, (II) Jy. 1891, Sheldon 1087 and 995; Blue Earth, (II) Jy. 1891, Sheldon 478; Mille Lacs, (II) Jy. 1892, Sheldon 2978; Hennepin, (II) O. 1892, Sheldon 4126.

Calyptospora J. KÜHN.

The well-known species on the mountain cranberry has been collected only in one locality.

1. **C. goeppertiana** KÜHN. Hedw. 8: 81. 1869.

On *Vaccinium vitis-idæa* L.: Cooke, (III) Jy. 1899, MacMillan; Cooke, (III) Jy. 1900, Mrs. C. J. Hibbard.

II. PUCCINIACEÆ.

Uromyces LINK.

Fourteen species of *Uromyces* have been found in the State. Seven of these are found upon plants of the Pulse family. Very common also are those species found upon *Euphorbia*, *Arisæma* and *Polygonum*. Four species belong to the *Hemiuromyces*, seven to the *Euuromyces* and of the remaining three, the life histories are incomplete. The *Euuromycetes* are all autœcious.

A. AUT-EUUROMYCES.

1. **U. fabæ** (P.) DE BARY, Ann. Sci. Nat. IV. **20**: 76. 1863.

Uromyces polymorphus Pk. * differs from this species only in greater variability of the teleutospore form. The pedicel is no criterion. I have therefore included forms on *Lathyrus* and *Vicia* under *U. fabæ* although exhibiting considerable variation in spore form.

* Ellis. N. A. Fungi no. 1442.

On *Vicia linearis* (NUTT.) GREENE: Traverse, (II) S. 1893, Sheldon 7374.
Vicia americana MUHL.: Mille Lacs, (II and III) Jy. 1892, Sheldon 2926.
Vicia sp. indet.: Traverse, S. 1893, Sheldon, (II) 7320 and (III) 7256; ——, (III) —— 1892, Sheldon 3816 (?).
Lathyrus venosus MUHL.: Mille Lacs, (II) Jy. 1892, Sheldon 2940.
Lathyrus sp. indet.: ——, (III) —— 1893, Sheldon 6127 and 6129.

2. **U. appendiculatus** (P.) LINK. Berl. Ges. Nat. Freunde Mag. **7**: 28. 1816.
On *Strophostyles helvola* (L.) BRITTON: Houston, (I) Je. 1899, Lyon 24; Houston, (II, III) Ag. 1899, Lyon 389.

3. **U. albus** DIET. & HOLW. Hedw. **36**: 297. 1897.

According to Dietel this is *Æcidium album* Clint. (*Æcidium porosum* Pk.). No experiments indicating this are cited. The specimen reported below differs from Dietel's description in that the teleutospore sori are found on the leaves (not on the stem), and the color of the sori is not black but dark brown.

This material (Holway 25) was reported by Arthur * as *Uromyces orobi* (P.) Wint. (II), and (Holway 14) as *Æcidium porosum*.

On *Vicia americana* MUHL.: St. Louis, (II, III) Jy. 1886, Holway 25; St. Louis, Jy. 1886, Holway 14; Mille Lacs, (I) Jy. 1892, Sheldon 2720; Aitkin, (I) Jy. 1892, Sheldon 2658.

4. **U. trifolii** (ALB. & SCHW.) Wint. Die Pilze 1^1: 159. 1884.
On *Trifolium repens* L.: St. Louis, (I, II) Jy. 1886, Holway 34; Hennepin, (II, III) Jy. 1890, MacMillan; ——, (II) —— 1893, Sheldon 6098.

5. **U. euphorbiæ** COOKE & PECK, Rep. N. Y. St. Mus. Nat. Hist. **25**: 90. 1873.

Arthur's recent experiment † although too incomplete to be conclusive indicates strongly that *Uromyces euphorbiæ* is an autœcious Euuromyces.

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* l. c.

† Cultures of Uredineæ in 1899. J. C. Arthur.

On *Euphorbia maculata* L.: Mille Lacs, (I) Jy. 1892, Sheldon 3136.

Euphorbia serpyllifolia Pers.: Pine, (II, III) Je. 1899, Freeman 528; Hennepin, (II, III) Jy. 1890, MacMillan.

Euphorbia heterophylla L.: Houston, (II, III) Ag. 1899, Lyon 317.

Euphorbia marginata PURSH: Renville, (II, III) Jy. 1891, Sheldon 957.

Euphorbia glyptosperma ENGELM.: Chisago, (II, III) Ag. 1892, Taylor 1568½; Brown, (II, III) Jy. 1891, Sheldon 969 and 1170.

Euphorbia sp. indet.: Renville, (II, III) 1890, MacMillan.

6. **U. polygoni** (P.) FCKL. Symb. Myc. 64. 1869.

Of this very common species uredospores and teleutospores only can at present be reported. Some æcidium material on what appeared to be a *Polygonum* was found in 1900 in Wright county (Freeman 698), but the amount of material was insufficient for accurate and positive determination.

On *Polygonum aviculare* L.: Winona, (III) on leaves and stem, N. and O. 1893, Edna Porter; St. Louis, (II) Jy. 1886, Holway 5, 113 and 116.

Polygonum ramosissimum MICHX.: Brown, (II, III) on leaves and stem, Jy. 1891, Sheldon 1048; Lincoln, (III) Ag. 1891, Sheldon 1545.

Polygonum sp. indet.: Traverse, (III) on leaves and stem, S. 1893, Sheldon 7253; Winona, (II, III) S. 1888, Holzinger.

7. **U. caladii** (SCHW.) FARLOW, Ellis N. A. Fungi, No. 232. 1879. Abundant wherever *Arisæma* is found.

On the leaves and spathe of:

Arisæma triphyllum (L.) TORR.: Blue Earth, (I) Je. 1891, Sheldon 114; Chisago, (III) S. 1893, Sheldon 6309; Hennepin, (I) My. 1899, Freeman 308; Ramsey, (I) My. 1899, Freeman 317; Houston, (I) Je. 1899, Lyon 97; Hennepin, (I) My. 1899, MacMillan; Hennepin, (I) F. 1899, E. A. Cuzner (in university plant house); Wright, (I) My. 1900, Freeman 581; Pope, (III) Jy. 1892, Taylor 916; Winona, My. 1889, Holzinger.

B. HEMIUROMYCES.

8. **U. lespedezæ** (SCHW.) PK. Ellis, N. A. Fungi, No. 245. 1879.
   On *Lespedeza capitata* MICHX.: Winona, (III) S. 1888, Holzinger; Chisago, (III) S. 1893, Ballard 1819.

9. **U. hedysari-paniculata** (SCHW.) FARLOW, Ellis, N. A. Fungi, No. 246. 1879.
   On *Meibomia* sp. indet.: ——, (III) 1893, Sheldon 7078.

10. **U. terebinthi** (DC.) WINT. Die Pilze [1[1]: 147. 1884.
   On *Rhus radicans* L.: Kandiyohi, (III) Jy. 1892, Frost 302.

11. **U. caryophyllinus** (SCHRANK.) SCHROET. Brand and Rost-Pilz. Schles. 10. 1872.
   On *Dianthus caryophyllus* L.: Ramsey, (III) on leaves and stem, Ap. 1900, Freeman.

C. LIFE HISTORIES INCOMPLETELY KNOWN.

12. **U. argophyllæ** SEYM. Proc. Bost. Soc. Nat. Hist. 185. 1889.
   On *Psoralea argophylla* PURSH: Traverse, (III) S. 1893, Sheldon 7353; Lincoln, (III) Ag. 1891, Sheldon 1546.

13. **U. pyriformis** COOKE, Rep. N. Y. St. Mus. Nat. Hist. **29**: 69. 1878.
   On *Acorus calamus* L.: Carver, (III) Je. 1891, Ballard 13; Wright, (III) My. 1900, Freeman 636.

14. **U. rudbeckiæ** ARTH. & HOLW. Bull. Ill. St. Lab. Nat. Hist. **2**: 163. 1885.
   On *Rudbeckia laciniata* L.: ——, (III) S. 1893, Sheldon.

Puccinia PERSOON.

Thirty-nine species have been collected: 10 *Aut-eupuccinia*, 6 *Heter-eupuccinia*, 2 *Brachypuccinia*, 2 *Pucciniopsis*, 7 *Hemipuccinia*, 1 *Micropuccinia*, 3 *Leptopuccinia*, and 8 with imperfectly known life histories. Very abundant are those species found on Mints, *Helianthus* and allied genera, on grasses, sedges and *Polygonum*. Those forms formerly included under *P. hieracii* (Schum.) Mart. have been separated as far as possible according to the recent researches of Jacky.* The high degree of specialization in the habit of these forms which has

*Die Compositen-bewohnenden Puccineen vom Typus Puccinia hieracii und deren Specialisierung. Bern. 1899.

been demonstrated in these experiments emphasizes the need of special research in cultures upon American species. It is possible to utilize Jacky's results only upon species common to both Europe and America. *Puccinia amorphæ* Curt. upon species of *Amorpha* have been retained under Schroeter's genus *Uropyxis*.

A. AUT-EUPUCCINIA.

1. **P. adoxæ** HEDW. Fl. Fr. 2: 220. 1815.
   On *Adoxa moschatellina* L.: Winona, (I) My. 1889, Holzinger.
2. **P. calthæ** LK. in Linné, Sp. Pl. 6[2]: 79. 1825.
   On *Caltha palustris* L.: St. Louis, (II) Jy. 1886, Holway 96.
3. **P. convolvuli** (P.) CAST. Obs. 1: 16. 1842.
   On *Convolvulus sepium* L.: Winona, (II, III) Ag. 1888, Holzinger; Brown, (I) Jy. 1893, Sheldon 899; Blue Earth, (I) Je. 1891; Sheldon 374.
   Convolvulus spithamæus L.: Winona, (III) Ag. 1888, Holzinger 6.
4. **P. galii** (P.) SCHWEIN. Syn. Fung. Car. Sup. 73. 1822.
   On *Galium asprellum* MICHX.: St. Louis, Jy. 1886, Holway 94.
   Galium concinnum TORR. & GRAY: Winona, Ag. 1888, Holzinger 198.
5. **P. gentianæ** (STRAUSS) LK. in Linné Sp. Pl. 6[2]: 73. 1825.
   On *Gentiana andrewsii* GRISEB.: Brown, (II, III) Jy. 1891, Sheldon.
   Gentiana puberula MICHX.: Glenwood, (II, III) Ag. 1891, Taylor 1179.
6. **P. pimpinellæ** (STRAUSS) LINK in Linné Sp. Pl. 6[2]: 77. 1825.
   On *Washingtonia claytoni* (MICHX.) BRITTON: Houston, (II, III) Je. 1899, Lyon 41.
7. **P. violæ** (SCHUM.) DC. Fl. Fr. 6: 92. 1815.
   On *Viola canadensis* L.: Lake, (I) Je. 1893, Sheldon 4758.
   Viola blanda WILLD.: St. Louis, (II, III) Jy. 1886, Holway 131; Lake, (I) Je. 1893, Sheldon 4735; Wright, (I) My. 1900, Freeman 662.

Viola blanda palustriformis A. GRAY: Hennepin, (I) My. 1891, Sheldon 5961.

Viola blanda amœna (LE CONTE) B.S.P.: Crow Wing, (I) Je. 1892, Sheldon 2150; Mille Lacs, (I) Jy. 1892, Sheldon 2705½.

Viola scabriuscula (T. & G.) SCHWEIN.: Wright, (I) My. 1900, Freeman 592.

Viola sp. indet.: Hennepin, (II, III) S. 1889, MacMillan; Brown, (III) Jy. 1891, Sheldon 845 and 850; Hennepin, (III) O. 1892, Sheldon 4090; ——, (III) S. 1893, Sheldon 7242.

8. **P. menthæ americana** BURRILL, Bull. Ill. St. Lab. Nat. Hist. **2**: 189–191. 1885.

The echination, which distinguishes this form from the European form, is in almost all specimens most marked at the apex of the teleutospores. Many teleutospores are almost smooth at the base. European teleutospore specimens are sometimes slightly echinate at the apex.

On *Monarda fistulosa* L.: Chisago, Ag. 1883, Arthur; Winona, (III) Ag. 1888, Holzinger 42; Winona, (II, III) Ag. 1888, Holzinger; Hennepin, (III) 1890, MacMillan; Hennepin, (III) O. 1893, Sheldon 4096; Traverse, (III) S. 1893, Sheldon 7175; Winona, (III) S. 1893, Edna Porter; Hennepin, (III) S. 1898, MacMillan; Houston, (III) Ag. 1899, Lyon 321.

Koellia virginiana (L.) MACM.: Winona, (II, III) Ag. 1888, Holzinger 164.

Mentha canadensis L: Hennepin, (II, III) Ag. 1883, Arthur; St. Louis, (II, III) Jy. 1886, Holway 236; Lincoln, (II, III) Ag. 1891, Sheldon 1419; Ramsey, (II) Je. 1899, Freeman 458; Ramsey, (II, III) S. 1898, Freeman.

Mentha sp. indet.: ——, (II, III) 1893, Sheldon 6070 and 7019; Traverse, (II, III) S. 1893, Sheldon 7382.

9. **P. tanaceti** DC. Fl. Fr. **2**: 222. 1815.

The *Puccinia* on *Helianthus* differs from that on *Tanacetum* only in having a slightly broader teleutospore. This is especially true of the distal cell. Culture experiments are necessary to separate these forms.

On *Artemisia dracunculoides* PURSH: Houston, (II, III) Ag. 1899, Lyon 391; Traverse, (III) S. 1893, Sheldon 7311.

Heliopsis helianthoides (L.) B.S.P.: Winona, (II, III) Jy. 1888, Holzinger 204.

Helianthus grosse-serratus MARTENS: Lincoln, (III) Ag. 1891, Sheldon 1544.

Helianthus tuberosus L.: Goodhue, (II, III) Ag. 1893, Anderson 726.

Helianthus giganteus L.: St. Louis, (II) Jy. 1886, Holway 133.

Helianthus annuus L.: Winona, (III) Ag. 1889, Holzinger; Hennepin, (II, III) O. 1889, MacMillan; McLeod, (II) Jy. 1890, T. J. McElligott; Hennepin, (III) —— 1890, E. A. Cuzner; Traverse, (III) S. 1893, Sheldon 7366; Ramsey, (III) S. 1898, Freeman; ——, (III) 1893, Sheldon, 5823, 6175 and (II, III) 7195; Hennepin, (II, III) O. 1889, MacMillan.

Helianthus sp. indet.: Traverse, (III) S. 1893, Sheldon 7378; ——, (III) 1893, Sheldon 7136 and 6067.

10. **P. Chondrillæ** CORDA, Icon. Fung. **4**: 15. 1840.

The Minnesota specimens of the *Puccinia* on *Lactuca* exhibit morphological characters which according to Jacky (l. c.) distinguish this form from those on *Prenanthes*. The teleutospore has no well-developed papilla and no constriction and is elliptical in form. The germ pores are irregular in position, often occurring at the summit.

On *Lactuca pulchella* (PURSH) DC.: ——, (III) S. 1893, Sheldon.

Lactuca sp. indet.: Traverse, (III) S. 1893, Sheldon 7241 and 7125.

B. HETER-EUPUCCINIA.

11. **P. angustata** PECK, Rep. N. Y. St. Mus. Nat. Hist. **25**: 123. 1873.

On *Scirpus atrovirens* MUHL.: Ramsey, (II, III) O. 1898, Freeman.

Lycopus virginicus L.: St. Louis, (I) Jy. 1886, Holway 216; Blue Earth, (I) Je. 1891, Sheldon 484.

This species is connected with *Æcidium lycopi* Ger. according to Arthur (l. c.).

12. **P. caricis** (SCHUM.) REBENT. Prod. Fl. Neom. 356. 1804.

The connection of *Æcidium urticæ* Schwein. on *Urtica* with *P. caricis* has been confirmed for American specimens. (Arthur, l. c.) The æcidia are found on both lamina and petiole.

On *Carex castanea* WAHL.: Lake, (III) Je. 1893, Sheldon 4822.

Carex utriculata BOOTT: Houston, (III) My. 1900, Lyon 537.

Carex sp. indet.: ——, (III) 1893, Sheldon 7135, 7368 and 7122; Hennepin, (III) O. 1898, Freeman; Hennepin, (III) S. 1900, Freeman 786½.

Urtica gracilis AIT.: Ramsey, (I) My. 1899, Freeman 322; Waseca, (I) Je. 1891, Sheldon 206 and Taylor 302.

Urtica sp. indet.: Hennepin, (I) 1893, Sheldon 5968 and 5967.

13. **P. phragmitis** (SCHUM.) KÖRN. Hedw. **15**: 179. 1876.

In Europe it has been demonstrated by several investigators that the æcidium on various species of *Rumex* belongs to *P. phragmitis.* According to the recent culture experiments of Arthur (l. c.) æcidia were easily obtained upon *Rumex crispus* and *Rumex obtusifolius.* According to the same author no authentic and undoubted record of the collection of *Æcidium rubellum* GMEL. has been reported upon American species of *Rumex.* A Minnesota specimen of *Rumex britannica* L. was collected in 1899 (Freeman 471) upon which several groups of æcidia were found. Upon comparison with *Æcidium rubellum* on *R. hydrolapathum* * the two specimens were found to agree perfectly in all morphological characters.

The spots are circular and usually of a reddish color, not swollen. Pseudoperidia on lower surface of the leaf somewhat crowded, leaving usually a free central area, flat, cup-shaped with revolute lacerate margin. Spores 17–23 $\mu \times$ 11–17 μ. It seems very probable therefore that this æcidium on *Rumex britannica* belongs to *P. phragmitis.* Arthur's explanation that the æcidium on *Rumex* has up to this time been overlooked is therefore probably correct.

On *Rumex britannica* L.: Ramsey, (I) Je. 1899, Freeman 471.

Phragmites phragmites (L.) KARST: ——,(III) 1893, Sheldon 7119.

14. **P. rhamni** (P.) WETTST. Verh. Zool.-Bot. Ges. Wien. **35**: 545. 1885. (*P. coronata* CDA.)

* Krieger Fung. Sax. no. 853.

On *Avena sativa* L.: Brown, (II) Jy. 1891, Sheldon 1045.
Rhamnus alnifolia L'HER.: Houston, (I) Ag. 1900, Lyon 546; Ramsey, (I) My. 1899, Freeman 316; ——, (I) 1893, Sheldon 5963; Hennepin, (I) My. 1891, Sheldon 5969.

15. **P. poculiformis** (JACQ.) WETT. Verh. Zool.-Bot. Ges. Wien. **35**: 544. 1885. (*P. graminis* PERS.)

There is no good reason for not accepting Wettstein's name. The species is exceedingly abundant although but few collections have been made.

On *Avena sativa* L.: Brown, (III) Jy. 1891, Sheldon 1104; Goodhue, (II) Ag. 1893, Anderson 710.
Undetermined grasses: ——, (II, III) 1893, Sheldon 7120; ——, (II), 1893, Sheldon 7126.

16. **P. rubigo-vera** (DC.) WINT. Die Pilze 1^1: 217. 1884.
On *Triticum vulgare* L.: Kandiyohi, (II) Jy. 1892, Frost 285 and (II, III) 283½; Goodhue, (II, III) Ag. 1893, Anderson 711; Traverse, (III) S. 1893, Sheldon 7387.
Hordeum vulgare L.: Waseca, (II, III) Je. 1891, Sheldon 529.

C. BRACHYPUCCINIA.

17. **P. hieracii** (SCHUM.) MART. Flora Mosq. 226. 1817.

Jacky's results (l. c.) can be utilized only in separating out the form on *Taraxacum*. Those on *Hieracium* and *Carduus* require further cultural investigation on American specimens.

On *Hieracium canadense* MICHX.: Hennepin, (III) O. 1889, MacMillan.
Carduus sp. indet.: Winona, (II) Ag. 1888, Holzinger 41; ——, (II, III) 1893, Sheldon 6097 and 6059; Traverse, (II, III) S. 1893, Sheldon 7398; Ramsey, (II, III) S. 1898, Freeman.

18. **P. taraxaci** PLOWRIGHT, Brit. Ured. and Ustil.: 186 and 187. 1889.

This species seems to be founded on negative results of Plowright and recently of Jacky. Inoculations with Pucciniæ from other composites gave in all cases negative results.

On *Taraxacum taraxacum* (L.) KARST.: Traverse, (II) S. 1893, Sheldon 7324; Hennepin, (II) Ag. 1883, Arthur; Ramsey, (II) My. 1899, Freeman 360; Hennepin, (II, III) S. 1898, Freeman.

D. PUCCINIOPSIS.

19. **P. grossulariæ** (GM.) WINT. Die Pilze I[1]: 198. 1884.
On *Ribes rubrum* L.: St. Louis, (III) Jy. 1886, Holway 213.

20. **P. podophylli** SCHWEIN. Syn. Fung. Car. Sup.: 72 No. 489. 1822.
On *Podophyllum peltatum* L.: Winona, (I) My. 1889, Holzinger; Winona, (III) Je. 1889, Holzinger; Houston, Je. 1899, Lyon (I) 2 and (III) 80.

E. HEMIPUCCINIA.

21. **P. polygoni-amphibii** P. Syn. Meth. Fungi 227. 1801. Very widely distributed and abundant.
On *Polygonum amphibium* L.: Hennepin, (II, III) S. 1889, MacMillan; ——, (II, III) 1893, Sheldon 6076.
Polygonum hartwrightii A. GRAY: Hennepin, (II, III) Ag. 1883, Arthur; Hennepin, (II, III) S. 1889, MacMillan; Otter Tail, (II, III) Ag. 1892, Sheldon 3897; Traverse, (II, III) S. 1893, Sheldon 7377.
Polygonum emersum (MICHX.) BRITTON: Hennepin, (II, III) Ag. 1883, Arthur; St. Louis, (II) Jy. 1886, Holway 50 and (II, III) Holway 48; Winona, (II, III) S. 1888, Holzinger 252.
Polygonum sp. indet.: Lincoln, (II, III) Ag. 1891, Sheldon 1549 and 1570; ——, (III) 1893, Sheldon 7137.

22. **P. argentata** (SCHULTZ) WINT. Die Pilze I[2]: 194. 1884.
On *Impatiens biflora* WALD.: Ramsey, (III) S. 1898, Freeman.

23. **P. pruni-spinosæ** PERS. Syn. Meth. Fung. 226. 1801.
On *Prunus pumila* L.: Crow Wing, (II, III) Ag. 1890, MacMillan and Sheldon 92.

24. **P. kuhniæ** SCHWEIN. Syn. Fung. Am. Bor. 296. 1834.
On *Kuhnia eupatorioides* L.: Ramsey, (III) S. 1898, Freeman.

25. **P. tomipara** TREL. Trans. Wisc. Acad. Sci. A. and L. 6: 23. 1884.
On *Bromus ciliatus* L.: St. Louis, (II) Jy. 1886, Holway 12. Also reported at Detroit (Becker Co.) in Ell. and Ever. N. A. Fungi No. 1842. 1884.

26. **P. sorghi** SCHWEIN. Syn. Fung. Am. Bor. 295. No. 2910. 1831.
On *Zea mays* L.: St. Louis, (II) Jy. 1886, Holway 136; ——, (II) 1893, Sheldon 6148; Brown, (II) Jy. 1891, Sheldon 1065.
Sorghum sp. indet.: Hennepin, (III) O., 1890, Sheldon 5742.

27. **P. emaculata** SCHWEIN. Syn. Fung. Am. Bor. 295. No. 2912. 1834.
On *Panicum capillare* L.: Lincoln, (III) Ag. 1891, Sheldon 1530; Traverse, (III) S. 1893, Sheldon 7375 7376.

F. MICROPUCCINIA.

28. **P. thalictri** CHEV. Fl. Paris. 1: 417. 1826.
On *Thalictrum* sp. indet.: Cass, (III) Jy. 1893, Anderson 573.

G. LEPTOPUCCINIA.

29. **P. asteris** DUBY, Botan. Gallic. 2: 888. 1828.
On *Aster macrophyllus* L.: St. Louis, Jy. 1886, Holway 37; Cass, Jy. 1893, Ballard 1652.
Aster sagittifolius WILLD.: Houston, Ag. 1899, Lyon 451.
Aster sp. indet.: Lake, Jy. 1886, Holway, 273.

There is a great similarity in the spots, sori and spores of *P. asteris* on *A. macrophyllus* to those of *P. xanthii* Schwein.

30. **P. circææ** PERS. Tent. Disp. Meth. 39. 1797.
On *Circæa alpina* L.: St. Louis, Jy. 1886, Holway 214.
Circæa lutetiana L.: Winona, Jy., 1888, Holzinger 206 and 132; Pope, Jy. 1891, Taylor 887.
Circæa sp. indet.: Cass, Jy. 1893, Ballard 1655.

31. **P. ornata** ARTH. & HOLW. Rep. Bot. Wk. in Minn. for year 1886, 3: 30. 1887.
On *Rumex britannica* L.: St. Louis, (III) Jy. 1886, Holway 223.
Rumex sp. indet.: Crow Wing, (III) Ag. 1890, MacMillan and Sheldon.

H. LIFE HISTORIES IMPERFECTLY KNOWN.

32. **P. variolans** HARK. Bull. Calif. Acad. Sci. 1: 35. 1884.
On *Eriocarpum spinulosum* (NUTT.) GREENE: Traverse, (III) S. 1893, Sheldon 7101.

33. **P. nardosmiæ** E. & E. Journn. Myc. 1: 85. 1885.
On *Petasites palmata* (AIT.) A. GRAY: St. Louis, (III) Jy. 1886, Holway 232.

34. **P. porphyrogenita** CURT. Thüm. Myc. Univ. No. 545. 1876.
On *Cornus canadensis* L.: St. Louis, (III) Jy. 1886, Holway 108; St. Louis, (III) Je. 1893, Sheldon 4622.

35. **P. hydrophylli** PECK & CLINT. Rep. N. Y. St. Mus. Nat. Hist. 30: 54. 1879.
On *Hydrophyllum virginicum* L.: Hennepin, (III) My. 1891, Sheldon 1968 and 1981; Meeker, (III) Je. 1892, Frost 37; Ramsey, (III) My. 1892, Sheldon 1969; Aitken, (III) Je. 1892, Sheldon 2072; ——, (III) 1893, Sheldon 5803; Hennepin, (III) My. 1899, Freeman 310.

36. **P. tiarellæ** B. & C. N. A. Fungi, No. 549. 1881.
On *Mitella nuda* L.: St. Louis, (III) Jy. 1886, Holway 62.

37. **P. haleniæ** ARTH. & HOLWAY, Rep. Bot. Wk. in Minn. 3: 30. 1886.
On *Tetragonanthus deflexus* (J. E. SMITH) KUNTZE: St. Louis, (III) Jy. 1886, Holway 100.

38. **P. mesomegala** B. & C. Grev. 3: 53. 1874.
On *Clintonia borealis* (AIT.) RAF.: St. Louis, (III) Jy. 1886, Holway 18.

39. **P. xanthii** SCHWEIN. Syn. Fung. Car. Sup. 500. 1822.
Berkeley and Ravenel have described a variety *ambrosiæ*. The spores on *Ambrosia* do not, however, differ morphologically from those on *Xanthium*.
On *Xanthium canadense* MILL.: Hennepin, (III) O. 1889, MacMillan; Brown, (III) Jy. 1891, Sheldon 861 and 1008; Carver, (III) Jy. 1891, Ballard 756; Lincoln, (III) Ag. 1891, Sheldon 1262; Otter Tail, (III) Ag. 1892, Sheldon 3898; Traverse, (III) S. 1893, Sheldon 7259; Hennepin, (III) S. 1898, Butters; Ramsey, (III) Jy. 1899, Freeman 531; Houston, (III) Ag. 1899, Lyon 458.
Ambrosia trifida L.: Lincoln, (III) Ag. 1891, Sheldon 1266; Brown, (III) Ag. 1891, Sheldon 1227.

Gymnoconia LAGERH.

Separated from *Puccinia* on account of the æcidia, which are destitute of a pseudoperidial wall and are at first covered only by the epidermis of the host.

1. **Gymnoconia interstitialis** (SCHLECT.) LAGERH. Ured. Herb. El. Fr. Tromsö. Mus. Arshefter **17**: 84. 1894. (*Cæoma nitens* SCHWEIN. and *Puccinia peckiana* HOWE.)

The æcidial stage (*Cæoma nitens* Schwein.), the common raspberry rust, is abundant throughout the State. The teleutospores have not yet been found in Minnesota.

On *Rubus strigosus* MICHX.: Mille Lacs, (I) Jy. 1892, Sheldon 2709.

Rubus villosus AIT.: Kanabec, (I) Jy. 1892, Sheldon 2908; Mille Lacs, (I) Jy. 1892, Sheldon 2713.

Rubus canadensis L.: Le Sueur, (I) Je. 1891, Sheldon 52; Aitkin, (I) Je. 1892, Sheldon 2061 and 2145; Pine, (I) Je. 1899, Freeman 499.

Rubus sp. indet.: Winona, (I) Je. 1888, Holzinger 235; Cass, (I) Je. 1893; Ballard 1393; Houston, (I) Je. 1899, Lyon.

Uropyxis SCHROETER.

The puccinia on *Amorpha* species (*P. amorphæ* Curt.) has here been retained under Schroeter's genus *Uropyxis*. The differences between *Uropyxis* and typical *Pucciniæ* are no less than those between *Phragmopyxis* and *Phragmidium*. On the other hand *P. deglubens* might be included among the *Pucciniæ* without much more serious objection than can be raised against *Puccinia clymi* Westd. *Puccinia petalostemonis* Farlow has a slight gelatinous exospore which certainly indicates relationship with the *Puccinia* on *Amorpha*. *Phragmopyxis* according to Dietel * is more closely related to *Uropyxis* than to *Phragmidium*. I have seen biseptate spores in *Puccinia petalostemonis* Farl.† The forms on the Leguminosæ, therefore, seem to form a natural group with sufficient distinguishing characters to separate them generically from the typical *Pucciniæ*. This is Schroeter's genus *Uropyxis*. *Puccinia petalostemonis* Farl. connects it with the true *Puccinæ*.

1. **U. amorphæ** (CURT.) SCHROET. Hedw. **15**: 165. 1875.

On *Amorpha canescens* PURSH: Winona, (III) S. 1888, Holzinger; Otter Tail, (III) Ag. 1892, Sheldon 3650; Traverse, (III) S. 1893, Sheldon 7111 and 7180; Ramsey, (III) S. 1898, Freeman; Pope, (III) Ag. 1891, Taylor 1182.

* l. c., 70.

† Ellis. N. A. Fungi, No. 1844.

Amorpha fruticosa L.: Traverse, (III) S. 1893, Sheldon 7243; Brown, (III) Jy. 1891, Sheldon 985; Chisago, (III) S. 1891, Sheldon 4245; Traverse, (III) S. 1893, Sheldon 7370.

The æcidial and uredo forms have not yet been collected.

Gymnosporangium De Candolle.

1. **G. globosum** Farl. Am. Mem. Bot. Soc. Nat. Hist. 18. 1880.

   On *Juniperus virginiana* L.: Dakota, (III) Ap. 1900, Lyon.

2. **G. nidus-avis** Thaxter, Bull. Conn. Ag. Ex. Sta. **107**: 6. 1891.

   On *Juniperus virginiana* L.: Wright, (III) Je. 1899, Lyon 553 and 547 and Freeman 697.

3. **G. clavariæforme** (Jacq.) Rees. Abh. Naturf. Gesell. **11**: 21. 1869.

   On branches of *Juniperus communis* L.: Hennepin, (III) A. 1901, Butters 97.

   Causes fusiform swelling of the branches.

4. **G. juniperi-virginianæ** Schw. Syn. Fung. Car. Sup. 74. No. 504. 1822. (*G. macropus* Lk.)

   On small branches of *Juniperus virginiana* L.: Wright, (III) A. 1901, Freeman 978.

   Causes swellings known as "cedar apples."

Phragmidium Link.

1. **P. potentillæ** (P.) Karst. Fungi Fen. No. 94 and 593. (Hel. Bid.) Fen. Nat. o. Folk. **19**: 1871—**23**: 1873.

   On *Potentilla pennsylvanica strigosa* Pursh: Douglas, (III) Ag. 1892, Sheldon 3481.

2. **P. rubi-idæi** (P.) Karst. Helsing. Bid. Fin. Nat. o. Folk **19**. 1871.

   On *Rubus strigosus* Michx.: Aitken, (II) Je. 1892, Sheldon 2211; St. Louis, (II, III) Jy. 1886, Holway 205.

   Rubus hispidus L.: St. Louis, (II) Jy. 1886, Holway 20.

   Rubus sp. indet.: Winona, (II) S. 1888, Holzinger.

3. **P. speciosum** Fr. Syst. Myc. **3**: 496. 1829.

   On stems of *Rosa* sp. indet.: Wright, (III) O. 1896, Washburn; Ramsey, (III) S. 1899, Wheeler.

4. **P. subcorticum** (Schrank.) Wint. Die Pilze 1^1: 228. 1884.

On *Rosa acicularis* LINDL.: St. Louis, (II, III) Jy. 1886, Holway 187 and 247; Ramsey, (III) My. 1899, Freeman 350.

Rosa blanda AIT.: Mille Lacs, (III) Je. 1890, Sheldon 2313.

Rosa sp. indet.: Hennepin, (III) O. 1898, Freeman; St. Louis, (II) Jy. 1886, Holway 3; Winona, (II, III) S. 1888, Holzinger; Hennepin, (III) O. 1898, Freeman; Houston, (III) Je. 1899, Lyon 26; (III) 1893, Sheldon 7334.

Triphragmium LINK.

1. **T. clavellosum** BERK. Gard. Chron. 1857.

On *Aralia nudicaulis* L.: St. Louis, (III) Jy. 1886, Holway 17.

Æcidium. ISOLATED FORMS.

1. **A. uvulariæ** SCHWEIN. Syn. Fung. Car. Sup. 69, no. 453. 1822.

On *Uvularia perfoliata* L.: Blue Earth, Je. 1891, Sheldon 295; Chisago, Je. 1892, Taylor 1255.

Uvularia grandiflora SM.: Ramsey, Je. 1899, Freeman 403; Pine, Je. 1899, Freeman 526; Houston, Je. 1899, Lyon 96; Houston, Je. 1900, Lyon 552.

Uvularia sessilifolia L.: Aitkin, Je. 1892, Sheldon 2066.

2. **A. iridis** GER. Rep. N. Y. St. Mus. Nat. Hist. **25**: 93. 1870.

On *Iris versicolor* L.: Kanabec, Jy. 1892, Sheldon 2886; Houston, My. 1900, Lyon 534.

3. **A. convallariæ** SCHUM. Enum. Plant. Saell. **2**: 224. 1803.

On *Lilium canadense* L.: Ramsey, Je. 1899, Freeman 400.

Polygonatum commutatum (SCH.) DIETR.: Ramsey, Je. 1899, Freeman 404.

Polygonatum sp. indet.: Houston, Je. 1899, Lyon 22.

4. **A. orobi** PERS. Röm. N. Mag. **1**: 92. 1794.

Probably belongs to *Uromyces fabæ* (P.) DE BARY.

(?) On *Falcata comosa* (L.) KUNTZE: Pope, Jy. 1891, MacMillan 5.

Apios apios (L.) MACM.: Brown, Jy. 1891, Sheldon 914.

5. **A. lupini** PECK, Rep. N. Y. St. Mus. Nat. Hist. **46**: 33. 1893.

On *Lupinus perennis* L.: Chisago, Jy. 1892, Taylor 1421.

6. **A. thalictri-flavi** (DC.) WINT. Die Pilze 1[1]: 269. 1884.
   On *Thalictrum dioicum* L.: Mille Lacs, Je. 1892, Sheldon 2306.
   Thalictrum purpurascens L.: St. Louis, Jy. 1886, Holway 210 (*A. thalictri* Grev.); Ramsey, Je. 1898, Freeman 71; Ramsey, My. 1899, Freeman 318.

7. **A. ranunculacearum** DC. Fl. Fr. **6**: 97. 1815.
   On *Anemone canadense* L.: Winona, Je. 1889, Holzinger, Ramsey, Je. 1899, Freeman.
   Anemone quinquefolia L.: Aitkin, Je. 1891, Sheldon 2312 and 2108; Mille Lacs, Je. 1892, Sheldon 2566.
   Ranunculus abortivus L.: Wright, My. 1899, Freeman 637½; St. Louis, Jy. 1886, Holway 212.

The æcidia on *R. abortivus* L. are not diffused over the entire surface but are aggregated on definite orbicular spots which are at first reddish but become yellow in drying. Spores finely tuberculate polygono-spherical, 20–23 × 17 μ. Not *Æcidium ranunculi* Schwein.

8. **A. punctatum** PERS. Usteri Ann. Bot. **20**: 135. 1796.
   On *Thalictrum dioicum* L.: Chisago, Je. 1899, Freeman 416.

9. **A. actææ** OPIZ. in Wallr. Fl. Crypt. Germ. **2**: 252. 1833.
   On *Actæa alba* (L.) MILL.: Blue Earth, Je. 1891, Sheldon 392.

10. **A. cimicifugatum** SCHWEIN. Syn. Fung. Am. Bor. 293. No. 2876. 1831.
    On *Actæa* sp. indet.: Pope, Jy. 1891, Taylor 889.

Differs from *A. cimicifugatum* Schwein. in the long cylindrical pseudoperidia and in smooth (or almost) spores. Spores 15–17 μ in diameter.

11. **A. clematidis** DC. Fl. Fr. **2**: 243. 1815.
    On *Clematis virginiana* L.: Mille Lacs, Jy. 1892, Sheldon 2764; Brown, Jy. 1891, Sheldon 907; Pope, Jy. 1892, MacMillan 6; Houston, Je. 1899, Lyon 106.

12. **A. fumariacearum** KELL. & SWINGLE, Journ. Myc. **4**: 95. 1888.
    On *Bicuculla cucullaria* (L.) MILLSP.: Aitkin, Je. 1892, Sheldon 2203; —— 1893, Sheldon 5959.

13. **A. geranii** DC. Syn. Pl. 47. 1806.

On *Geranium maculatum* L.: Crow Wing, Je. 1892, Sheldon 2247; Meeker, Je. 1892, Frost 61; Houston, Je. 1899, Lyon 95; Ramsay, My. and Je. 1899, Freeman 329 and 419; Winona, Je. 1888, Holzinger.

Belongs probably to *Uromyces geranii* (DC.) Wint.

14. **A. impatientis** SCHWEIN. Syn. Fung. Car. 674. No. 442. 1822.

On *Impatiens biflora* WALT.: Winona, Je. 1889, Holzinger; Pope, Jy. 1891, Taylor 826; Waseca, Je. 1891, Sheldon 520; Le Sueur, Je. 1891, Sheldon 219; Mille Lacs, Je. 1892, Sheldon 2495.

Impatiens sp. indet.: Pope, Jy. 1892, MacMillan 3; Wright, Je. 1900, Freeman 686.

15. **A. verbenæ** SPEG. Fung. Argent. **1**: 56. 1880.

On *Verbena stricta* VENT.: Brown, Jy. 1891, Sheldon 1080.

16. **A. jacobeæ** GREV. Fl. Edin. 445. 1824. (*A. senecionis* DESMAZ.)

In European specimens connected with *Puccinia Schœleriana* Plow. et Magn.

On leaves of *Senecio aureus* L., Ramsey, My. 1899, Freeman 328.

17. **A. compositarum** MART. Fl. Erlang. 314. 1817.

The æcidia on composites vary considerably in the form and color of the spots, the arrangement of the æcidia and in the size and form of the spores. In the absence of necessary knowledge of the life-histories of these forms only a temporary classification is possible. Their separation into varieties based on the hosts is the only convenient method.

On *Hieracium canadense* Michx.: Ramsey, Je. 1899, Freeman 396; Chisago, Je. 1899, Freeman 425.

On *Adopogon virginicum* (L.) KUNTZE: Ramsey, Je. 1899, Freeman 392.

Var. **erigerontis** WINT.

On *Erigeron annuus* (L.) PERS.: Houston, Je. 1899, Lyon 85.

Var. **prenanthis** (P.) WALLR. Fl. Crypt. Germ. no. 1773. 1833.

On *Nabalus* sp. indet.: Houston, Je. 1899, Lyon 12; Chisago, Je. 1899, Freeman 423.

Var. **lactucæ** BURRILL, Bull. Ill. St. Lab. Nat. Hist. **2**: 232. 1885.

On *Lactuca canadensis* L.: Pine, Je. 1899, Freeman 475; Ramsey, Je. 1898, Freeman 69; Chisago, Je. 1899, Freeman 418.

Lactuca ludoviciana (NUTT.) DC.: Le Sueur, Je. 1891, Sheldon 29½ and 244.

Lactuca sp. indet.: Ramsey, My. Freeman 344; Wright, My. 1900, Freeman 594.

Var. **liatrii** WEBBER, Journn. Myc. **5**. 1889.

On *Laciniaria* sp. indet.: Pine, Je. 1899, Freeman 514.

Var. **helianthi** BURRILL, l. c. 232.

On *Helianthus divaricatus* L.: Blue Earth, Je. 1891, Sheldon 281.

Helianthus sp. indet.: Le Sueur, Je. 1891, Taylor 265.

Var. **eupatorii** (SCHW.) BURRILL, l. c. 231.

On *Eupatorium purpureum* L.: Ramsey, Je. 1899, Freeman 464.

Eupatorium perfoliatum L.: Brown, Ag. 1891, Sheldon 1058; Waseca, Je. 1891, Sheldon 308 and 521; Chisago, Je. 1892, Taylor 1340.

Eupatorium ageratoides L.: Ramsey, Je. 1898, Freeman 70.

18. **A. asterum** SCHWEIN. Syn. Fung. Car. Sup. 67, No. 444. 1822.

On *Solidago flexicaulis* L.: Waseca, Jy. 1891, Sheldon 657.

Solidago serotina AIT.: Mille Lacs, Jy. 1892, Sheldon 2790.

Solidago sp. indet.: St. Louis, Jy. 1886, Holway 141 (*A. compositarum*); Blue Earth, Je. 1891, Sheldon 207; Mille Lacs, Je. 1892, Sheldon 2451; Wright, My. 1900, Freeman 595.

Aster sagittifolius WILLD.: Blue Earth, Je. 1891, Sheldon 258.

Aster sp. indet.: Waseca, Je. 1891, Sheldon 566; Houston, Je. 1899, Lyon 14; Ramsey, Je. 1899, Freeman 398.

Euthamia graminifolia (L.) NUTT.: Chisago, Je. 1899, Freeman 430; Chisago, Je. 1892, Taylor 1339.

19. **A. pustulatum** CURT., Rep. N. Y. St. Mus. Nat. Hist. **23**: 60. 1869.
On *Comandra umbellata* (L.) NUTT.: Winona, Je. 1888, Holzinger; Wright, Je. 1900, Freeman 691; Ramsey, Je. 1899, Freeman 394; Pine, Je. 1899, Freeman 490; Houston, Je. 1899, Lyon 90. Very abundant throughout the State.

20. **A. jamesianum** PECK, Bot. Gaz. **5**: 34. 1880.
On *Asclepias syriaca* L.: Brown, Jy. 1891, Sheldon 1078.
Asclepias tuberosa L.: Brown, Jy. 1891, Sheldon 787.
Acerates viridiflora (RAF.) EATON: Houston, Je. 1899, Lyon.

21. **A. lysimachiæ** (SCHL.) WALLR. Fl. Crypt. Germ. No. 1770. 1833.
On *Steironema ciliatum* (L.) RAF.: Pine, Je. 1899, Freeman 503.

22. **A. grossulariæ** PERS. Syn. Meth. Fung. (?). 1801. (*A. grossulariæ* SCHUM. Enum. Plant. Saell. **2**: 223. 1803.) Abundant everywhere.
On *Ribes gracile* MICHX.: Winona, My. 1886, Holzinger; Brown, Jy. 1891, Sheldon 826½; Ramsey, My. 1899, Freeman 315.
Ribes floridum L'HER.: Le Sueur, Je. 1891, Sheldon 233; Blue Earth, Je. 1891, Sheldon 375; Ramsey, My. 1899, Freeman 326; Wright, Je. 1900, Lyon 550; Houston, Je. 1899, Lyon.
Ribes cynosbati L.: Aitkin, Je. 1892, Sheldon 2291; Wright, My. 1900, Freeman 660; Pope, Jy. 1891, Taylor 935; Chisago, Je. 1892, Taylor 1307.
Ribes sp. indet.: Blue Earth, Je. 1891, Sheldon 375; Hennepin, My. 1891, Sheldon; Meeker, Je. 1892, Frost 33; Lake, Je. 1893, Sheldon 4928; Hennepin, 1893, Sheldon 5966; Houston, Je. 1900, Lyon 551; Wright, My. 1900, Freeman 598; Houston, Je. 1899, Lyon 13.

23. **A. hydnoideum** B. & C. Grev. **3**: 61. 1874.
On *Dirca palustris* L.: Chisago, S. 1891, Sheldon, 1984½; Crow Wing, Jy. 1893, Ballard 1496 and 1646; Wright, My. 1900, Freeman 579.

24. **A. hydrophylli** PECK, Rep. N. Y. St. Mus. Nat. Hist. **26**: 78. 1874.
On *Hydrophyllum virginicum* L.: Mille Lacs, Je. 1891, Sheldon 2475 and 2822; Ramsay, Je. 1899, Freeman 397; Wright, My. 1900, Freeman 600.

25. **A. pammelii** TREL. Trans. Wis. Acad. Sc. A. and L. **6**: 33. 1884.
On *Euphorbia corollata* L.: Houston, Jy. 1899, Lyon.

26. **A. peckii** DETONI, Syll. Fung. **7**: 790. 1888.
On *Onagra biennis* (L.) SCOP.: Pope, Jy. 1891, Taylor 865; Waseca, Je. 1891, Sheldon 510; Waseca, Je. 1892, Taylor 479; Ramsey, Jy. 1898, Freeman 72; Hennepin, My. 1899, Freeman 337; Pine, Je. 1899, Freeman 508 and 498.

27. **A. phrymæ** HALST. Journ. Myc. **2**: 52. 1886.
On *Phryma leptostachya* L.: Waseca, Je. 1891, Sheldon 564; Brown, Ag. 1891, Sheldon 1000.

28. **A. fraxini** SCHWEIN. Syn. Fung. Car. Sup. 66. No. 430. 1822.
On *Fraxinus Americana* L.: Lincoln, Ag. 1891, Sheldon 1520; Brown, Jy. 1891, Sheldon 1205.
Fraxinus sp. indet.: Brown, Jy. 1891, Sheldon 1076; Kandiyohi, Jy. 1892, Frost 292.

Peridermium LEV.

1. **P. balsameum** PK. Rep. N. Y. St. Mus. Nat. Hist. **27**: 104. 1875.
On *Abies balsamea* (L.) MILL.: St. Louis, Jy. 1886, Holway 208.

The spores of this specimen are uniformly smaller than those described by Peck and agree more nearly with those of *A. elatinum*. No distortion of the branches has been reported. The spores measure 14 × 17–20 μ.

2. **P. abietinum** (A. & S.) THÜM. var. **decolorans** THÜM.
On *Picea mariana* (MILL.) B.S.P.: St. Louis, Jy. 1886, Holway 93.

The spores agree with those of the æcidia of *Chrysomyxa ledi*, to which this species supposedly belongs.

Uredo. Isolated Forms.

1. **U. polypodii** (P.) DC. Fl. Fr. 6: 81. 1815.
   On *Cystopteris fragilis* Bernh.: Houston, Jy. 1899, Lyon 217.

2. **U. agrimoniæ-eupatoriæ** (DC.) Wint. Die Pilze 1^1: 252. 1884.
   On *Agrimonia hirsuta* (Muhl.) Bicknell: St. Louis, Jy. 1886, Holway 209.

PLATE XXXII.

THE HELIOTYPE PRINTING CO. BOSTON

XXX. A NEW SPECIES OF ALARIA.

De Alton Saunders.

During the summer of 1896 while investigating some physiological problems in the Hopkins Sea-side laboratory, the writer collected an *Alaria* which did not seem to agree with any of the described species. No specimens of the Pacific coast *Alarias* were at hand for comparison and the writer being loath to add further to the synonymy of this variable group laid the plant aside until a favorable opportunity for study should present itself. Recently a specimen of this plant with several other species of Alaskan algæ was submitted to Dr. Kjellman who pronounced it a new species, related to his *A. prælonga* and *A. angusta*.

Alaria curtipes nov. sp. (Plate XXXIII.)

Plant of medium size, one to three or more meters long, dark olive brown, coriaceous; stipe very short (1–4 cm. long), firm, robust, black, narrowed below, but little flattened above; rachis short, somewhat compressed, gradually passing into the midrib; blade linear or narrowly lanceolate, 1–3 dcm. wide, narrowed above; midrib prominent, 1–2 cm. broad, projecting equally on both surfaces of the blade, quadrangular in cross section; sporophylls ovate, lanceolate or elliptical, obtusely rounded above, 2–3 cm. wide, 7–15 cm. long, 16–40 or more borne seriately on a distinct stalk 5–10 mm. long; fruiting area confined to the lower half of the sporophylls.

Abundant on exposed rocky points on the central Californian coast, Monterey bay, Carmel bay, and Point Sur.

A. curtipes is related to *A. prælonga* * Kjellm., and *A. angusta* † Kjellm. but according to Dr. Kjellman's comparison "Differs from *A. prælonga* in its broader midrib and its shorter

* Kjellman. Om Beringshafv. Algflora, p. 38, T. 4, Figs. 1–4.
† Ibidem, p. 38, T. 3, Figs. 1–4.

and more robust stipe. It differs from *A. angusta* especially in the form of the sporophylls."

Explanation of Plate XXXIII.

Figure 1. Mature plant reduced ½; *a*, *b*, *c*, *d*, young plants, showing different stages of development.

Figure 2. Cross section of sporophylls, × 400.

Figure 3. Section of midrib, × 2.

XXXI. A PRELIMINARY LIST OF MINNESOTA XYLARIACEÆ.

F. K. Butters.

During the past fifteen years numerous collections of Minnesota fungi have been made by E. W. D. Holway, Esq., Dr. A. P. Anderson, Messrs. E. P. Sheldon, E. M. Freeman and others. The list given below comprises records of all the Xylariaceæ which have been collected within the State and deposited in the herbarium of the University of Minnesota. In each case the county in which the collection was made is cited, with the date of collection, and such other information as is deemed of special value. A list of the fungi collected by Holway was included in Professor J. C. Arthur's report on botanical work in Minnesota for the year 1886,* but they are included in the present list for the sake of completeness. Some of Mr. Sheldon's specimens as well as the fungi included in Professor Arthur's list have been previously determined, but in all cases the fungi reported in the following list have been examined personally by the author and he takes the sole responsibility for their correct determination. In cases where the determinations as given in Arthur's list have been altered the name as it appears in that list has been inserted in parentheses after the citation of the collection.

In all cases in which the nomenclature employed departs from that found in Ellis and Everhart's North American Pyrenomycetes, the name employed in that work is inserted as a synonym.

It is to be noted that the specimens distributed by Ellis † as *Hypoxylon rubiginosum* (Pers.) Fr. are certainly of a different species from those distributed by de Thümen ‡ and other Euro-

* Geological and Natural History Survey of Minnesota, Bulletin No. 3, Oct. 1, 1887.

† Ellis & Everhart. North American Fungi, 1949, Fungi Columbiani, 1324.

‡ *Mycotheca universalis*, 1071.

pean authors. De Thümen's specimens are cited by Winter * and are probably authentic. The specimens distributed by Ellis cannot be *Hypoxylon rubiginosum* (Pers.) Fr. They agree with the fungus upon *Magnolia* described by Berkeley † as *Hypoxylon epiphæum* B. & C. (in some works spelled *epiphlæum*) and the species has been so cited in the following list.

In all, nineteen species of Xylariaceæ are included in the list given below. They are distributed among five genera as follows: *Nummularia*, 3; *Ustulina*, 1; *Hypoxylon*, 12; *Daldinia*, 2; *Xylaria*, 1.

Owing to the somewhat desultory manner in which these collections of fungi have been made, many species which doubtless occur in the State have not been collected as yet, while some of the more abundant and more noticeable species have been collected many times.

1. **Nummularia nummularia** (BULLIARD) SCHROET. Krypt. Fl. von Pilze II. 459. 1897. (*N. bulliardi* TUL.)

Hennepin, April 1890, Sheldon 14, on *Quercus;* ——‡ Sheldon 5751⅓; Wright, May 1900, Freeman 658 on *Quercus;* Hennepin, September 1900, Butters 75, on *Acer;* Hennepin, October 1900, Butters 50, on *Acer*.

2. **Nummularia repanda** (FRIES) NITSCHKE, Pyrenomycetes Germanici, p. 57. 1867.

Hennepin, May 1893, Sheldon 5428, on *Cornus?* erumpent through the bark; ——, Sheldon 5765; ——, Sheldon 5781.

3. **Nummularia lateritia** ELLIS & EVERHART, New Species of North American Fungi, Proc. Ac. Nat. Sci. Philadelphia, p. 144. 1893.

On bark.

Hennepin, May 1891, Sheldon 4193, on *Populus;* Hennepin, May 1891, Sheldon 4197; Ramsey, May 1893, Sheldon 4327, on *Acer;* ——, Sheldon 5928, on *Populus*.

4. **Ustulina maxima** (HALLER) SCHRÖTER, Kryptogamen Flora von Schlesien, Pilze II. p. 465. 1897. (*Ustulina vulgaris* TUL.)

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* Die Pilze, II., p. 860.

† Notices of North American Fungi, Grevillea, IV. 52. 1875.

‡ Mr. Sheldon's last field note-book is missing, his collections concerning which no field notes can be found are indicated as above.

Crow Wing, June 1892, Sheldon 2238; Ramsey, August 1893, Sheldon 5528; Hennepin, June 1890, Sheldon 5696; ——, Sheldon 6138⅓; Hennepin, May 1899, Freeman 306; Ramsey, June 1899, Freeman 380; Wright, May 1900, Freeman 650½.

Conidial stage: Wright, June 1900, Freeman 684.

5. **Hypoxylon petersii** BERKELEY & CURTIS, On a Collection of Fungi from Cuba, Journ. Linn. Soc., X., p. 384. 1869.

Houston, August 1899, Wheeler 476, on decayed log; Hennepin, September 1900, Freeman 702, on *Quercus*.

6. **Hypoxylon fuscum** (PERS.) FRIES, Summa Veg. Scand. p. 384. 1849.

On bark.

St. Louis, July 1886, Holway 119, on *Alnus;* St. Louis, July 1886, Holway 151, on *Alnus;* Hennepin, May 1891, Sheldon 4195; Lake, June 1893, Sheldon 4749, on *Alnus;* Dakota, July 1893, Sheldon 5372; Hennepin, October 1900, Butters 51, on *Ostrya*.

7. **Hypoxylon commutatum** NITSCHKE, Pyrenomycetes Germanici, p. 33. 1867.

On bark.

St. Louis, July 1886, Holway 144, on *Alnus;* Lake, June 1893, Sheldon 4484, on *Betula;* Hennepin, May 1891. Sheldon 5904, on *Tilia*.

8. **Hypoxylon granulosum** BULLAIRD, Champ. Fr. 176. 1791 (*H. multiforme* FR.) Summa Veg. Scand. p. 384. 1849.

St. Louis, July 1886, Holway 248, on *Alnus* (*Hypoxylon commutatum Holwayanum* Sacc. Holway); St. Louis, July 1886, Holway 262, on *Betula;* St. Louis, June 1893, Sheldon 4669; Ramsey, July 1893, Sheldon 5490, on wood; ——, Sheldon 6012, on *Betula;* erumpent through the bark.

9. **Hypoxylon morsei** BERKELEY & CURTIS, Notices of North American Fungi, Grevillea, IV., p. 51. 1875.

Erumpent through the bark.

St. Louis, July 1886, Holway 41, on *Betula* (*Hypoxylon transversum* Schw. Holway); St. Louis, July 1886, Holway 99, on *Alnus*; Le Sueur, June 1891, Taylor, 364; Hennepin, May 1891, Sheldon; Crow Wing, June 1892, Sheldon 2054, on *Quercus;* Hennepin, April 1891, Sheldon 4178, on *Quercus;* Dakota, July 1893, Sheldon 5201, on *Quercus;* Hennepin, May 1893, Sheldon 5426, on *Quercus;* ——, Sheldon 6138; ——, Sheldon 6244; on *Quercus;* Wright, June 1900, Lyon 542, on *Rhus;* Chisago, September 1900, Lyon & Butters, on *Quercus.*

10. **Hypoxylon annulatum** (SCHW.) MONTAGNE, Sylloge Cryptogramarum, p. 213. 1856.

Cass, August 1893, Anderson 674, on wood.

11. **Hypoxylon marginatum** BERKELEY, On a Collection of Fungi from Cuba. Part II., Journ. Lin. Soc., X., p. 499. 1869.

Dakota, July 1893, Sheldon 5194 on bark.

12. **Hypoxylon rubiginosum** (PERS.) FRIES, Summa Veg. Scand., p. 384. 1849.

On wood.

St. Louis, July 1886, Holway 193 (*Hypoxylon ferrugineum* Fr. Holway & Ellis), Ramsey, July 1893, Sheldon 5484; Wright, May 1900, Freeman 630.

13. **Hypoxylon perforatum** (SCHW.) FRIES, Summa Veg. Scand., p. 384. 1849.

——, Sheldon 5904½; ——, Sheldon 6133.

14. **Hypoxylon epiphæum** BERKELEY & CURTIS, Notices of North American Fungi, Grevillea, IV., p. 52. 1875.

Hypoxylon rubiginosum Ellis & Everhart, North American Fungi, No. 1949, not *H. rubiginosum* (Pers.) Fries.

Hypoxylon epiphlœum B. & C.

On wood.

Le Sueur, June 1891, Taylor 435; Brown, July 1891, Sheldon 1027, on *Tilia;* Ramsey, July 1893, Sheldon 5503, on *Acer?* (young form).

15. **Hypoxylon atropurpureum** (FRIES) FRIES, Summa Veg. Scand., p. 384. 1849.

On wood.

Le Sueur, June 1891, Sheldon 94; Brown, July 1891, Sheldon 1027½, on *Tilia;* Ramsey, August 1893, Sheldon 5669; ——, Sheldon 5751, on *Quercus;* ——, Sheldon 6236.

16. **Hypoxylon serpens** (PERS.) FRIES, Summa Veg. Scand., p. 384. 1849.

St. Louis, July 1886, Holway 265, on *Populus*.

17. **Daldinia tuberosa** (SCOP.) Voss. Myc. Carn. 180. 1891. (*D. concentrica* (BOLT.) C. & N.) Schema di Classificazione degli Sferiacei Italici aschigeri, Comment. Soc. Crittog. Ital., I., p. 198. 1863.

St. Louis, July 1886, Holway 256; Ramsey, September 1889, Sheldon, 18; Ramsey, May 1890, Sheldon 4340; Hennepin, April 1891, Sheldon 4191; Blue Earth, June 1891, Sheldon 408; Crow Wing, June 1892, Sheldon 2186; Hennepin, August 1893, Sheldon 5590; Hennepin, September 1893, Sheldon 5695; Cass, July 1893, Anderson 521; Cass, September 1898, MacMillan & Freeman 108; Wright, May 1900, Freeman 650; Wright, May 1900, Freeman, 654; Chisago, September 1900, Butters 85; Hennepin, September 1900, Butters 71; Hennepin, September 1900, Butters 73.

Conidial stage.

Waseca, July 1891, Taylor 670; Chisago, September 1900, Butters 87; Hennepin, October 1900, Butters 62.

18. **Daldinia vernicosa** (SCHW.) CESATI & DE NOTARIS, Schema di classificazione degli Sferiacei Italici aschigeri, Comment. Soc. Crittog. Ital. I, p. 198. 1863.

Ramsey, May 1890, Sheldon; Chisago, September 1900, Butters 86; Hennepin, October 1900, Butters 55; Hennepin, October 1900, Butters 88.

19. **Xylaria clavata** (SCOP.) SCHRANCK, Baierische Flora, II., p. 566. 1789. (*Xylaria polymorpha* (Pers.) Greville.)

Hennepin, April 1891, Sheldon 4170; Hennepin, April 1891, Sheldon 4182; Hennepin, August 1893, Sheldon 5581; ——, Sheldon 6138⅔; Hennepin, July 1899, Butters; Hennepin, September 1900, Freeman 784.

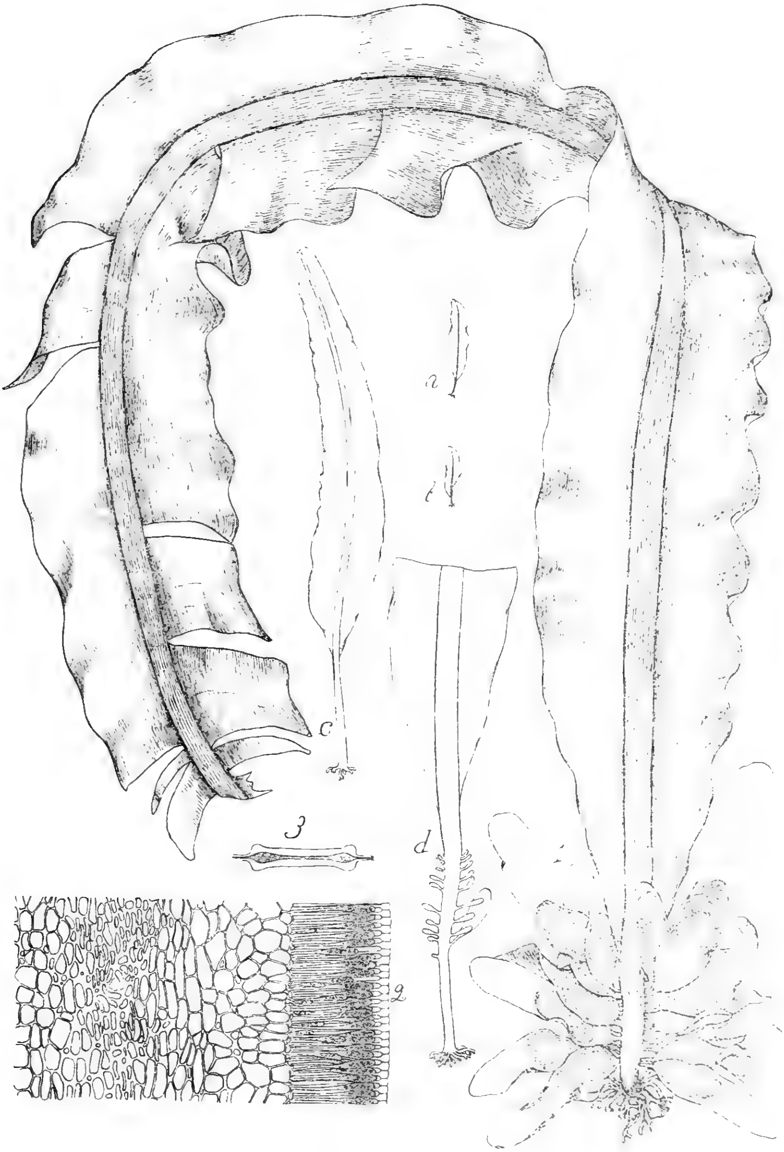


PLATE XXXIII.

THE HELIOTYPE PRINTING CO., BOSTON.

XXXII. A CONTRIBUTION TO THE KNOWLEDGE OF THE FLORA OF THE RED RIVER VALLEY IN MINNESOTA.

W. A. Wheeler.

During August, 1900, collections were made by the Botanical Survey in the valley of the Red River of the North. Professor Conway MacMillan, A. S. Skinner and C. J. Hibbard explored the region around Crookston through Polk and Red Lake counties and Professor C. A. Ballard visited Kittson, Marshall and Otter Tail counties. Professor MacMillan's party visited Crookston, Shirley, Holmes station and the region around Maple lake near Dugdale and Mentor in Polk county and Thief River Falls, Red lake Falls, St. Hilaire, Wylie and Ives in Red Lake county. Professor Ballard visited St. Vincent, Humboldt, Northcote, Hallock and Kennedy in Kittson county, Marshall in Warren county and Fergus Falls in Otter Tail county.

The collections made at these stations, scattered as they are through the Minnesota part of the Red River valley give a good representation of the late summer flora of this region.

The following plants were gathered of which there have been no definite authentic collections previously reported from Minnesota.

Puccinellia airoides (Nutt.) Wats. & Coult.
Elymus macouni Vasey.
Scirpus campestris Britton.
Juncus dudleyi Wiegand.
Rumex occidentalis S. Wats.
Chenopodium ambrosioides L.
Atriplex patula L.
Potentilla effusa Dougl.
Chamærhodos erecta (L.) Bunge.
Lappula americana (A. Gray) Rydberg.
Chrysopsis hispida (Hook.) Nutt.

As a result of the reconnoissance 325 species of flowering plants are reported below, 73 of which are monocotyledons and 252 dicotyledons.

Concerning the explorations made by Professor C. A. Ballard he wrote as follows under date of September 1, 1900:

The object of the present work was to examine certain portions of the Red River valley to determine (1) whether the soil of the sections under examination contained saline or alkaline ingredients in sufficient quantities to produce a distinctively characteristic vegetation, and (2) to note the extent of territory affected by such conditions.

I found it very difficult to obtain definite information as to the most pronounced alkaline regions of the valley, so that the territory covered is a part only of the sections under discussion.

I examined first, the vegetation, littoral and aquatic, of Mineral, Alkali and Horse Shoe lakes. These lakes are situated south and east of Fergus Falls, Otter Tail Co., and are more or less strongly alkaline. Of the three examined Mineral lake alone has a vegetation differing from that of the surrounding country. I have collected in this lake *Ruppia occidentalis*, in former years although unable to find it at this time. It is without doubt growing in the lake. Around the margin of the lake three or four chenopods grow luxuriantly. I next spent about two weeks in the northern part of the valley collecting in the vicinity of the following towns: St. Vincent, Humboldt, Northcote, Hallock and Kennedy in Kittson Co., and Warren in Marshall Co.

The monotonous dead level of the prairie is broken occasionally by small streams each with its fringe of trees. The surface wells of the region visited are alkaline, some of them decidedly so. This shows the entire soil to be alkaline to a certain extent. These wells are from 15 to 25 feet deep. Many deep wells have been sunk throughout the valley, those in Kittson Co. generally yielding a strong brine ($NaCl$) if more than 70 feet deep. I visited one such flowing well at Humboldt, the waters of which had killed all the vegetation for rods along the path of the flow. These conditions are so recent however that no marked halophytic vegetation has developed. Near a similar well at Northcote I found *Salicornia* growing abundantly within narrow limits.

Besides these localities of artificial conditions there is an occasional salt spring in the valley, notably one on "Two Rivers" some miles west of Hallock. I was unable to reach this spring. The numerous depressions in the surface of the prairie also often show slight incrustations of an alkaline salt.

At Hallock I had the good fortune to examine the herbarium of Mr. G. A. Gunnarson, the Auditor of Kittson Co. This herbarium of 200 to 300 plants represents the collections of several years in the immediate vicinity of Hallock. These plants were the ordinary types of the prairie and woodland of that region. One plant, however, *Plantago eriopoda*, is worthy of note as being a salt lover; it was collected 15 miles southeast of Hallock on sandy alkali soil. I afterwards found this plant growing sparsely six miles east of Warren.

As a result of my observations I draw the following conclusions: The soil of the entire valley is alkaline. The alkalinity is strongly marked in small localities only, which are popularly called "alkali spots." In Kittson and Marshall counties there are a few similar "salt spots," natural and artificial.

There are few halophytes in the valley; I found but two which I considered purely halophytic, these are B. 2680 *Salicornia*, growing in a coulee which had formerly drained a salt well at Northcote; and B. 2789 *Plantago*, growing in somewhat elevated sandy soil near Warren. There are also four chenopods, B. 2701, B. 2702, B. 2787, and B. 2576, which are semi-halophytic in character. These grow quite generally in many places in the valley, but are most numerous and luxuriant on the beaches of alkali lakes and ponds and in the vicinity of alkali spots.

A more thorough study of the region visited will doubtless add to the list of halophytes of the State and certainly extend the range of those already noted.

The principal object of Professor MacMillan, in his visit to the valley, was to secure a series of characteristic photographs of vegetation and portraits of plants to illustrate the flora of the region. There are presented herewith some views selected by him and made under his direction by Mr. C. J. Hibbard, Photographer of the Survey. They will serve to give an idea of the vegetation-sheet in the district covered by the list and will indicate some details of ecological distribution as suggested in the descriptions of the plates written by Professor MacMillan.

LIST OF SPECIES.

SPARGANIACEÆ.

Sparganium eurycarpum Engelm. in A. Gray, Man. Ed. 2, 430. 1856.

Coll.: MacMillan & Skinner 131, Maple lake; 398, Holmes.

Sparganium simplex Huds. Fl. Angl. Ed. 2, 401. 1788.

Coll.: Ballard 2581, Humboldt.

NAIADACEÆ.

Potamogeton perfoliatus L. Sp. Pl. 126. 1753.
Coll.: Ballard 2651, St. Vincent; MacMillan & Skinner 173, Maple lake.

Potamogeton pectinatus L. Sp. Pl. 126. 1753.
Coll.: Ballard 2652, St. Vincent; MacMillan & Skinner 172, Maple lake.

SCHEUCHZERIACEÆ.

Triglochin maritima L. Sp. Pl. 339. 1753.
Coll.: MacMillan & Skinner 112, Dugdale.

ALISMACEÆ.

Alisma plantago-aquatica L. Sp. Pl. 342. 1753.
Coll.: Ballard 2583, Humboldt; 2746, Hallock; MacMillan & Skinner 24, 417, Crookston.

Sagittaria latifolia Willd. Sp. Pl. 409. 1806.
Coll.: MacMillan & Skinner 10, Crookston; 370, Holmes.

Sagittaria arifolia Nutt.; J. G. Smith, Ann. Rep. Mo. Bot. Gard. 6: 32. 1894.
Coll.: Ballard 2580, Humboldt; 2657, St. Vincent.
Previously reported from Minnesota by J. G. Smith in Ann. Rep. Mo. Bot. Gard. 6: 33. 1895.

NYMPHÆACEÆ.

Nymphæa advena Soland, in Ait. Hort. Kew. 2: 226. 1789.
Coll.: MacMillan & Skinner 396, Holmes.

VALLISNERIACEÆ.

Philotria canadensis (Michx.) Britton, Science (II) 2: 5. 1895.
Coll.: MacMillan & Skinner 23, Crookston.

GRAMINEÆ.

Andropogon scoparius Michx. Fl. Bor. Am. 1: 57. 1803.
Coll.: MacMillan & Skinner 254, Crookston.

Andropogon furcatus Muhl.: Willd. Sp. Pl. 4: 919. 1806.
Coll.: Ballard 2598, Humboldt; 2769, Hallock; MacMillan & Skinner 357, Shirley.

Chrysopogon avenaceus (MICHX.) BENTH. Journ. Linn. Soc. **19**: 73. 1881.
Coll.: MacMillan & Skinner 64, Crookston.

Panicum crus-galli L. Sp. Pl. 56. 1753.
Coll.: Ballard 2589, Humboldt; 2699, Northcote; MacMillan & Skinner 128, 129, Maple lake.

Panicum pubescens LAM. Encycl. **4**: 748. 1797.
Coll.: MacMillan & Skinner 138, Maple lake.

Panicum virgatum L. Sp. Pl. 59. 1753.
Coll.: MacMillan & Skinner 341, 342, Crookston.

Panicum capillare L. Sp. Pl. 58. 1753.
Coll.: Ballard 2541, Fergus Falls; 2663, St. Vincent.

Chætochloa viridis (L.) SCRIBN. U. S. Dept. Agr., Div. Agros. Bul. 4: 39. 1897.
Coll.: Ballard 2525, Fergus Falls; 2686, Northcote.

Zizania aquatica L. Sp. Pl. 991. 1753.
Coll.: MacMillan & Skinner 134, Maple lake.

Muhlenbergia racemosa (MICHX.) B.S.P. Prel. Cat. N. Y. 67. 1888.
Coll.: Ballard 2693, Northcote; 2754, Hallock; MacMillan & Skinner 99, 101, Dugdale.

Alopecurus geniculatus L. Sp. Pl. 60. 1753.
Coll.: Ballard 2584, Humboldt; 2747, Hallock; MacMillan & Skinner 305, 306, Crookston.

Sporobolus brevifolius (NUTT.) SCRIBN. Mem. Torr. Club, **5**: 39. 1895.
Coll.: MacMillan & Skinner 329, Crookston.

Sporobolus cuspidatus (TORR.) WOOD, Bot. & Fl. 385. 1870.
Coll.: MacMillan & Skinner 275, St. Hilaire; 384, Holmes.

Sporobolus heterolepis A. GRAY, Man. 576. 1848.
Coll.: MacMillan & Skinner 387, Holmes.

Agrostis alba L. Sp. Pl. 63. 1753.
Coll.: MacMillan & Skinner 233, Crookston.

Spartina cynosuroides (L.) WILLD. Enum. 80. 1809.
Coll.: Ballard 2585, Humboldt; 2695, Northcote; 2762, Hallock; 2794, Warren; MacMillan & Skinner 52, Crookston.

Bouteloua oligostachya (NUTT.) TORR.; A. Gray, Man. Ed. 2, 553. 1856.
Coll.: MacMillan & Skinner 103, Dugdale.

Bouteloua curtipendula (MICHX.) TORR. Emory's Rep. 153. 1848.
Coll.: MacMillan & Skinner 46, Crookston.

Beckmannia erucæformis (L.) HOST, Gram. Austr. **3**: 5. 1805.
Coll.: Ballard 2588, Humboldt; 2634, St. Vincent; 2714, Northcote; 2745, Hallock; 2778, Warren; MacMillan & Skinner 100, Dugdale; 361, Crookston.

Phragmites phragmites (L.) KARST. Deutsch Fl. 379. 1880–83.
Coll.: MacMillan & Skinner 394, Holmes.

Eragrostis hypnoides (LAM.) B.S.P. Prel. Cat. N. Y. 69. 1888.
Coll.: Ballard 2672, St. Vincent; 2751, Hallock.

Kœleria cristata (L.) PERS. Syn. **1**: 97. 1805.
Coll.: MacMillan & Skinner 102, Dugdale; 337, Crookston.

Panicularia americana (TORR.) MACM. Met. Minn. Val. 81. 1892.
Coll.: Ballard 2582, Humboldt.

Puccinellia airoides (NUTT.) WATS. & COULT. in A. Gray, Man. Ed. 6, 668. 1890.
Coll.: Ballard 2528, Fergus Falls.
Not previously reported from Minnesota.

Bromus ciliatus L. Sp. Pl. 76. 1753.
Coll.: Ballard 2782, Warren; MacMillan & Skinner 35, Crookston; 106, Dugdale.

Bromus purgans L. Sp. Pl. 76. 1753.
Coll.: Ballard 2666, St. Vincent; 2755, Hallock; MacMillan & Skinner 28, Crookston.

Bromus kalmii A. GRAY, Man. 600. 1848.
Coll.: MacMillan & Skinner 105, Dugdale.

Agropyron repens (L.) BEAUV. Agrost. 146. 1812.
Coll.: Ballard 2621, Humboldt; 2715, Northcote.

Agropyron tenerum VASEY, Coult. Bot. Gaz. 10: 258. 1885.
Coll.: MacMillan & Skinner 304, 335, Crookston; Ballard 2569, St. Vincent.

Hordeum jubatum L. Sp. Pl. 85. 1753.
Coll.: Ballard 2520, Fergus Falls.

Elymus virginicus L. Sp. Pl. 84. 1753.
Coll.: Ballard 2629, St. Vincent; MacMillan & Skinner 235, Crookston.

Elymus canadensis L. Sp. Pl. 83. 1753.
Coll.: Ballard 2599, Humboldt; 2713, Northcote; MacMillan & Skinner 68, Crookston; 267, St. Hilaire.

Elymus macouni VASEY, Bull. Torr. Club, **13**: 119. 1886.
Coll.: Ballard 2570, St. Vincent.
Not previously reported from Minnesota.

Hystrix hystrix (L.) MILLSP. Fl. W. Va. 474. 1892.
Coll.: MacMillan & Skinner 107, Maple lake; 265, St. Hilaire.

CYPERACEÆ.

Cyperus diandrus TORR. Cat. Pl. N. Y. 90. 1819.
Coll.: Ballard 2537, Fergus Falls.

Cyperus speciosus VAHL, Enum. **2**: 364. 1806.
Coll.: MacMillan & Skinner 130, Maple lake.

Eleocharis acicularis (L.) R. & S. Syst. **2**: 154. 1817.
Coll.: MacMillan & Skinner 141, Maple lake.

Eleocharis intermedia (MUHL.) SCHULTES, Mant. **2**: 91. 1824.
Coll.: Ballard 2656, St. Vincent.

Scirpus lacustris L. Sp. Pl. 48. 1753.
Coll.: Ballard 2587, St. Vincent, MacMillan & Skinner 104, Maple lake.

Scirpus campestris BRITTON, in Britton & Brown, Ill. Fl. **1**: 267. 1896.
Coll.: Ballard 2539, 2544, Fergus Falls. Not previously reported from Minnesota.

Scirpus atrovirens MUHL. Gram. 43. 1817.
Coll.: MacMillan & Skinner 126, 127, Dugdale; 390, Holmes; 310, Crookston.

Carex utriculata Boott; Hook. Fl. Bor. Am. **2**: 221. 1840.
Coll.: MacMillan and Skinner 139, Maple lake; 381, Holmes.

Carex retrorsa Schwein. Ann. Lyc. N. Y. **1**: 71. 1824.
Coll.: MacMillan & Skinner 423, Crookston.

Carex fusca All. Fl. Ped. **2**: 269. 1785.
Coll.: MacMillan & Skinner 133, Maple lake.

Carex cristatella Britton, in Britton & Brown, Ill. Fl. **1**: 357. 1896.
Coll.: MacMillan & Skinner 249, Red Lake Falls.

Carex sychnocephala Carey, Am. Journ. Sci. (II.) **4**: 24. 1847.
Coll.: MacMillan & Skinner 307, Crookston.

ARACEÆ.

Arisæma triphyllum (L.) Torr. Fl. N. Y. **2**: 239. 1843.
Coll.: MacMillan & Skinner 237, Gentilly.

Calla palustris L. Sp. Pl. 968. 1753.
Coll.: MacMillan & Skinner 174, Maple lake.

Acorus calamus L. Sp. Pl. 324. 1753.
Coll.: MacMillan & Skinner 282, Thief River Falls.

LEMNACEÆ.

Lemna trisulca L. Sp. Pl. 970. 1753.
Coll.: Ballard 2654, St. Vincent; MacMillan & Skinner 410, Holmes.

Lemna minor L. Sp. Pl. 970. 1753.
Coll.: Ballard 2546, Fergus Falls.

JUNCACEÆ.

Juncus balticus Willd. Berlin Mag. **3**: 298. 1809.
Coll.: MacMillan & Skinner 136, Maple lake; 401, Holmes.

Juncus vaseyi Engelm. Trans. St. Louis Acad. Sci. **2**: 450. 1866.
Coll.: MacMillan & Skinner 135, Maple lake.

Juncus dudleyi Wiegand, Bull. Torr. Club, **27**: 524. 1900.
Coll.: MacMillan & Skinner 137, Maple lake; 276, Wylie.

Not previously reported from Minnesota. Many specimens however have been previously collected and reported as *Juncus tenuis* Willd.

Juncus nodosus L. Sp. Pl. Ed. 2, 466. 1762.
Coll.: Ballard 2741, Hallock; MacMillan & Skinner 373, Holmes.

Juncus torreyi Coville, Bull. Torr. Club, **22**: 303. 1895.
Coll.: MacMillan & Skinner 340, Crookston.

Juncus acuminatus Michx. Fl. Bor. Am. **1**: 192. 1802.
Coll.: Ballard 2743, Hallock.

LILIACEÆ.

Allium stellatum Ker, Bot. Mag. *pl. 1576.* 1813.
Coll.: MacMillan & Skinner 63, Crookston; 87, Dugdale.

CONVALLARIACEÆ.

Vagnera racemosa (L.) Morong, Mem. Torr. Club, **5**: 114. 1894.
Coll.: MacMillan & Skinner 148, Maple lake.

Vagnera stellata (L.) Morong, Mem. Torr. Club, **5**: 114. 1894.
Coll.: MacMillan & Skinner 218, Crookston.

Unifolium canadense (Desf.) Greene, Bull. Torr. Club, **15**: 287. 1888.
Coll.: MacMillan & Skinner 147, Maple lake.

Polygonatum commutatum (R. & S.) Dietr.; Otto & Dietr. Gartenz. **3**: 222. 1835.
Coll.: MacMillan & Skinner 17, Crookston.

SMILACEÆ.

Smilax herbacea L. Sp. Pl. 1030. 1753.
Coll.: MacMillan & Skinner 18, 319, Crookston; Ballard 2758, Hallock.

IRIDACEÆ.

Iris versicolor L. Sp. Pl. 39. 1753.
Coll.: MacMillan & Skinner 308, Crookston.

SALICACEÆ.

Populus balsamifera L. Sp. Pl. 1034. 1753.
Coll.: MacMillan & Skinner 278, Ives.

Salix lucida MUHL. Neue Schrift. Ges. Nat. Fr. Berlin **4**: 239. *pl. 6. f. 7.* 1803.
Coll.: MacMillan & Skinner 366, Holmes.

BETULACEÆ.

Corylus americana WALT. Fl. Car. 236. 1788.
Coll.: MacMillan & Skinner 415, Crookston.

Betula papyrifera MARSH. Arb. Am. 19. 1785.
Coll.: MacMillan & Skinner 178, Maple lake.

Betula glandulosa MICHX. Fl. Bor. Am. **2**: 180. 1803.
Coll.: Ballard 2803, Warren.

Alnus alnobetula (EHRH.) K. KOCH, Dendr. **2**: Part 1, 625. 1872.
Coll.: MacMillan & Skinner 151, Maple lake.

FAGACEÆ.

Quercus alba L. Sp. Pl. 996. 1753.
Coll.: Ballard 2753, Hallock.

Quercus macrocarpa MICHX. Hist. Chen. Am. 2. *pl. 23.* 1801.
Coll.: MacMillan & Skinner 280, Thief River Falls.

MORACEÆ.

Humulus lupulus L. Sp. Pl. 1028. 1753.
Coll.: MacMillan & Skinner 26, Crookston.

URTICACEÆ.

Urtica gracilis AIT. Hort. Kew. **3**: 341. 1789.
Coll.: MacMillan & Skinner 199, Crookston.

Urticastrum divaricatum (L.) KUNTZE, Rev. Gen. Pl. 635. 1891.
Coll.: MacMillan & Skinner 193, Crookston.

POLYGONACEÆ.

Rumex verticillatus L. Sp. Pl. 334. 1753.
Coll.: MacMillan & Skinner 158, Maple lake.

Rumex occidentalis S. WATS. Proc. Am. Acad. **12**: 253. 1876.
Coll.: MacMillan & Skinner 270, Thief River Falls.
Not previously reported from Minnesota.

Rumex crispus L. Sp. Pl. 335. 1753.
Coll.: Ballard 2628, St. Vincent; 2777, Warren; MacMillan & Skinner 189, Crookston; 389, Holmes.

Rumex persicarioides L. Sp. Pl. 335. 1753.
Coll.: Ballard 2638, St. Vincent; MacMillan & Skinner 155, Maple lake.

Polygonum emersum (MICHX.) BRITTON, Trans. N. Y. Acad. Sci. **8**: 73. 1889.
Coll.: MacMillan & Skinner 412, Crookston.

Polygonum lapathifolium L. Sp. Pl. 360. 1753.
Coll.: MacMillan & Skinner 2, Crookston; 294, Maple lake; Ballard 2590, Humboldt; 2673, St. Vincent.

Polygonum persicaria L. Sp. Pl. 361. 1753.
Coll.: MacMillan & Skinner 6, Crookston.

Polygonum punctatum ELL. Bot. S. C. & Ga. **1**: 455. 1817.
Coll.: MacMillan & Skinner 293, Maple lake; Ballard 2530, Fergus Falls.

Polygonum littorale LINK in Schrad. Journ. **1**: 54. 1799.
Coll.: Ballard 2643, 2670, St. Vincent; 2685, Northcote.

Polygonum erectum L. Sp. Pl. 363. 1753.
Coll.: Ballard 2720, Kennedy.

Polygonum exsertum SMALL, Bull. Torr. Club, **21**: 172. 1894.
Coll.: Ballard 2786, Warren.

Polygonum ramosissimum MICHX. Fl. Bor. Am. **1**: 237. 1803.
Coll.: Ballard 2551, 2636, St. Vincent; 2600, Humboldt; MacMillan & Skinner 142, Dugdale.

Polygonum convolvulus L. Sp. Pl. 364. 1753.
Coll.: Ballard 2602, Humboldt; MacMillan & Skinner 56, Crookston.

Polygonum scandens L. Sp. Pl. 364. 1753.
Coll.: MacMillan & Skinner 167, Maple lake.

CHENOPODIACEÆ.

Chenopodium album L. Sp. Pl. 219. 1753.
Coll.: Ballard 2552, 2575, St. Vincent; 2740, Hallock; 2527, Fergus Falls; 2708, Northcote; 2594, Humboldt; 2721, Kennedy; MacMillan & Skinner 19, Crookston. 119, Maple lake.

Chenopodium glaucum L. Sp. Pl. 220. 1753.
Coll.: Ballard 2529, 2531, Fergus Falls; 2576, St. Vincent.

Chenopodium leptophyllum (Moq.) Nutt.: Moq. in DC. Prodr. 13, Part 2, 71. As synonym. 1849.
Coll.: MacMillan & Skinner 332, Crookston.

Chenopodium hybridum L. Sp. Pl. 219. 1753.
Coll.: Ballard 2558, St. Vincent; MacMillan & Skinner 225, Crookston.

Chenopodium ambrosioides L. Sp. Pl. 219. 1753.
Coll.: Ballard 2635, St. Vincent; 2595, Humboldt; 2687, Northcote; 2761, Hallock; 2787, Warren; MacMillan & Skinner 424, Crookston.

No previous authentic collection reported from Minnesota.

Atriplex patula L. Sp. Pl. 1053. 1753.
Coll.: Ballard 2577, St. Vincent; 2614, 2625, Humboldt; 2702, Northcote; 2760, 2771, Hallock; 2722, Kennedy; 2772, Warren; 2532, Fergus Falls.

No previous authentic collection reported from Minnesota.

Salicornia herbacea L. Sp. Pl. Ed. 2, 5. 1762.
Coll.: Ballard 2680, Northcote.

"Growing locally along the drainage from a salt well. No other plants found growing with it." Ballard.

Dondia depressa (Pursh) Britton in Britton & Brown, Ill. Fl. *f. 1395.* **1**: 585. 1896.
Coll.: Ballard 2613, 2618, Humboldt; 3701, Northcote; 2759, Hallock; 2793, Warren; MacMillan & Skinner 113, Dugdale; 408, Crookston.

AMARANTHACEÆ.

Amaranthus retroflexus L. Sp. Pl. 991. 1753.
Coll.: Ballard 2632, St. Vincent; 2707, Northcote; 2717, Kennedy; MacMillan & Skinner 321, Crookston.

Amaranthus blitoides S. Wats. Proc. Am. Acad. **12**: 273. 1877.
Coll.: Ballard 2543, Fergus Falls; MacMillan & Skinner, 407, Crookston.

Amaranthus græcizans L. Sp. Pl. 990. 1753.
Coll.: Ballard 2658, St. Vincent; 2603, Humboldt; 2691, Northcote; 2718, Kennedy.

NYCTAGINACEÆ.

Allionia hirsuta Pursh, Fl. Am. Sept. 728. 1814.
Coll.: MacMillan & Skinner 91, Dugdale.

CARYOPHYLLACEÆ.

Agrostemma githago L. Sp. Pl. 435. 1753.
Coll.: MacMillan & Skinner 125, Dugdale.

Silene antirrhina L. Sp. Pl. 419. 1753.
Coll.: MacMillan & Skinner 124, Dugdale.

Vaccaria vaccaria (L.) Britton, in Britton & Brown Ill. Fl. **2**: 18. 1897.
Coll.: Ballard 2671, St. Vincent.

Alsine media L. Sp. Pl. 272. 1753.
Coll.: Ballard 2736, Kennedy.

CERATOPHYLLACEÆ.

Ceratophyllum demersum L. Sp. Pl. 992. 1753.
Coll.: Ballard 2654½, St. Vincent.

RANUNCULACEÆ.

Actæa alba (L.) Mill. Gard. Dict. Ed. 8, No. 2. 1768.
Coll.: MacMillan & Skinner 140, Maple lake.

Anemone cylindrica A. Gray, Ann. Lyc. N. Y. **3**: 221. 1836.
Coll.: Ballard 2606, Humboldt.

Anemone virginiana L. Sp. Pl. 540. 1753.
Coll.: Ballard 2526, Fergus Falls; MacMillan & Skinner 27, Crookston.

Anemone canadensis L. Syst. Ed. 12, **3**: App. 231. 1768.
Coll.: MacMillan & Skinner 39, Crookston.

Clematis virginiana L. Amoen. Acad. **4**: 275. 1759.
Coll.: MacMillan & Skinner 186, Maple lake.

Ranunculus scleratus L. Sp. Pl. 551. 1753.
Coll.: Ballard 2644, St. Vincent; 2586, Humboldt; MacMillan & Skinner 427, Crookston.

Ranunculus pennsylvanicus L. f. Suppl. 272. 1781.
Coll.: Ballard 2507, Fergus Falls; 2642, St. Vincent; 2756, Hallock; MacMillan & Skinner 22, Crookston; 288, Maple lake.

Oxygraphis cymbalaria (PURSH) PRANTL, in Engl. & Prantl, Nat. Pfl. Fam. **3**: Abt. 2, 63. 1891.
Coll.: Ballard 2508, Fergus Falls; 2645, St. Vincent; 2788, Warren; MacMillan & Skinner 409, Holmes.

Thalictrum purpurascens L. Sp. Pl. 546. 1753.
Coll.: MacMillan & Skinner 32, Crookston.

BERBERIDACEÆ.

Caulophyllum thalictroides (L.) MICHX. Fl. Bor. Am. **1**: 205. 1803.
Coll.: MacMillan & Skinner 286, Thief River Falls.

MENISPERMACEÆ.

Menispermum canadense L. Sp. Pl. 340. 1753.
Coll.: Ballard 2661, St. Vincent; MacMillan & Skinner 194, Crookston.

CRUCIFERÆ.

Thlaspi arvense L. Sp. Pl. 646. 1753.
Coll.: Ballard 2573, St. Vincent; 2579, Humboldt; 2690, Northcote.

Roripa palustris (L.) BESS. Enum. 27. 1821.
Coll.: Ballard 2709, Northcote; MacMillan and Skinner 214, Crookston.

Roripa hispida (DESV.) BRITTON, Mem. Torr. Club, **5**: 169. 1894.
Coll.: Ballard 2639, St. Vincent.

Sophia hartwegiana (FOURN.) GREENE, Pittonia, **3**: 95. 1896.
Coll.: MacMillan & Skinner 363, Crookston.

Erysimum cheiranthoides L. Sp. Pl. 661. 1753.
Coll.: MacMillan & Skinner 5, 197, Crookston.

CRASSULACEÆ.

Penthorum sedoides L. Sp. Pl. 432. 1753.
Coll.: MacMillan & Skinner 231, Crookston; Ballard 2780, Warren.

PARNASSIACEÆ.

Parnassia caroliniana Michx. Fl. Bor. Am. 1: 184. 1803.
Coll.: MacMillan & Skinner 94, Maple lake.

Parnassia palustris L. Sp. Pl. 273. 1753.
Coll.: Ballard 2512, Fergus Falls.

ROSACEÆ.

Spiræa salicifolia L. Sp. Pl. 489. 1753.
Coll.: Ballard 2706, Northcote; MacMillan & Skinner 156, Maple lake.

Rubus strigosus Michx. Fl. Bor. Am. 1: 297. 1803.
Coll.: MacMillan & Skinner 3, Crookston.

Potentilla leucocarpa Rydberg, in Britton & Brown, Ill. Fl. 2: 212. *f. 1924.* 1897.
Coll.: Ballard 2641, St. Vincent; MacMillan & Skinner 323, Crookston.

Potentilla monspeliensis L. Sp. Pl. 499. 1753.
Coll.: Ballard 2515, Fergus Falls; 2728, Kennedy; MacMillan and Skinner 72, 291, Crookston.

Potentilla pennsylvanica strigosa Pursh, Fl. Am. Sept. 356. 1814.
Coll.: MacMillan & Skinner 40, Crookston; 252 Red Lake Falls; 374, Holmes.

Potentilla effusa Dougl.; Lehm. Stirp. Pug. 2: 8. 1830.
Coll.: MacMillan & Skinner 385, Holmes.
No previous authentic collection reported from Minnesota.

Argentina anserina (L.) Rydberg, Mem. Dept. Bot. Columbia Univ. 2: 159. *pl. 98.* 1898.
Coll.: Ballard 2574, St. Vincent; 2626, Humboldt; MacMillan & Skinner 191, 221, Crookston.

Comarum palustre L. Sp. Pl. 502. 1753.
Coll.: MacMillan & Skinner 143, Maple lake.

Drymocallis arguta (Pursh) Rydberg, Mem. Dept. Bot. Columbia Univ. 2: 192. *pl. 102.* 1898.
Coll.: MacMillan & Skinner 90, Dugdale; 251, Crookston; 377, Holmes.

Chamærhodos erecta (L.) Bunge, in Ledeb. Fl. Alt. **1**: 430. 1829.
Coll.: MacMillan & Skinner 375, Holmes.
Not previously reported from Minnesota.

Geum virginianum L. Sp. Pl. 500. 1753.
Coll.: MacMillan & Skinner 213, Crookston; 250, Red Lake Falls; 369, Holmes; Ballard 2557, St. Vincent.

Agrimonia hirsuta (Muhl.) Bicknell, Bull. Torr. Club, **23**: 509. 1896.
Coll.: MacMillan & Skinner 354, Shirley.

Rosa arkansana Porter, Syn. Fl. Col. 38. 1874.
Coll.: Ballard 2681, Northcote; MacMillan & Skinner 328, Crookston.

POMACEÆ.

Cratægus coccinea L. Sp. Pl. 476. 1753.
Coll.: Ballard 2562, St. Vincent.
The determination of this is doubtful. It is the common form in northwestern Minnesota and Manitoba.

DRUPACEÆ.

Prunus americana Marsh, Arb. Am. 111. 1785.
Coll.: MacMillan & Skinner 192, 315, Crookston.

Prunus serotina Ehrh. Beitr. **3**: 20. 1788.
Coll.: MacMillan & Skinner 168, Maple lake.

PAPILIONACEÆ.

Lotus americanus (Nutt.) Bisch. Litt. Ber. Linnæa, **14**: 132. 1840.
Coll.: Ballard 2771½, Hallock.

Psoralea argophylla Pursh, Fl. Am. Sept. 475. 1814.
Coll.: Ballard 2608, Humboldt; MacMillan & Skinner 49, Crookston.

Amorpha fruticosa L. Sp. Pl. 713. 1753.
Coll.: Ballard 2505, Fergus Falls; MacMillan & Skinner 160, Maple lake.

Amorpha nana Nutt. Fras. Cat. 1813.
Coll.: Ballard 2800, Warren; MacMillan & Skinner 356, Shirley.

Kuhnistera candida (WILLD.) KUNTZE, Rev. Gen. Pl. 192. 1891.
Coll.: MacMillan and Skinner 247, Red Lake Falls.

Kuhnistera purpurea (VENT.) MACM. Met. Minn. Val. 329. 1892.
Coll.: Ballard 2610, Humboldt; 2765, Hallock; MacMillan & Skinner 62, Crookston.

Astragalus carolinianus L. Sp. Pl. 757. 1753.
Coll.: MacMillan & Skinner 66, Crookston.

Phaca neglecta T. & G. Fl. N. A. **1**: 344. 1838.
Coll.: MacMillan & Skinner 149, 153, Maple lake.

Glycyrrhiza lepidota PURSH, Fl. Am. Sept. 480. 1814.
Coll.: Ballard 2705, Northcote; MacMillan & Skinner 273, St. Hilaire.

Meibomia canadensis (L.) KUNTZE, Rev. Gen. Pl. 195. 1891.
Coll.: MacMillan & Skinner 85, Maple lake.

Vicia americana MUHL.; Willd. Sp. Pl. **3**: 1096. 1803.
Coll.: Ballard 2767, Hallock; MacMillan & Skinner 79, Dugdale.

Falcata comosa (L.) KUNTZE, Rev. Gen. Pl. 182. 1891.
Coll.: MacMillan & Skinner 162, Maple lake; 212, Crookston.

GERANIACEÆ.

Geranium bicknellii BRITTON, Bull. Torr. Club, **24**: 92. 1897.
Coll.: MacMillan & Skinner 145, Maple lake.

OXALIDACEÆ.

Oxalis stricta L. Sp. Pl. 435. 1753.
Coll.: MacMillan & Skinner 428, Crookston.

LINACEÆ.

Linum sulcatum RIDDELL, Suppl. Cat. Ohio Pl. 10. 1836.
Coll.: MacMillan & Skinner 108, Dugdale.

RUTACEÆ.

Xanthoxylum americanum MILL. Gard. Dict. Ed. 8, no. 2. 1768.
Coll.: MacMillan & Skinner 157, Maple lake.

EUPHORBIACEÆ.

Euphorbia serpyllifolia PERS. Syn. 2: 14. 1807.
Coll.: Ballard 2665, St. Vincent; 2682, Northcote; 2774, Warren.

Euphorbia glyptosperma ENGELM. Bot. Mex. Bound. Surv. 187 1859.
Coll.: Ballard 2604, 2605, Hallock; 2734, Kennedy.

Euphorbia maculata L. Sp. Pl. 455. 1753.
Coll.: Ballard 2664, St. Vincent.

ANACARDIACEÆ.

Rhus glabra L. Sp. Pl. 265. 1753.
Coll.: MacMillan & Skinner 195, Crookston.

ACERACEÆ.

Acer saccharum MARSH. Arb. Amer. 4. 1785.
Coll.: MacMillan & Skinner 182, Maple lake.

Acer negundo L. Sp. Pl. 1056. 1753.
Coll.: MacMillan and Skinner 422, Crookston.

BALSAMINACEÆ.

Impatiens biflora WALT. Fl. Car. 219. 1788.
Coll.: Ballard 2500, Fergus Falls.

VITACEÆ.

Vitis vulpina L. Sp. Pl. 203. 1753.
Coll.: MacMillan & Skinner 166, Maple lake.

TILIACEÆ.

Tilia americana L. Sp. Pl. 514. 1753.
Coll.: MacMillan & Skinner 320, Crookston.

HYPERICACEÆ.

Triadenum virginicum (L.) RAF. Fl. Tell. 3: 79. 1836.
Coll.: MacMillan & Skinner 165, Maple lake.

CISTACEÆ.

Lechea stricta LEGGETT; Britton, Bull. Torr. Club, 21: 251. 1894.
Coll.: MacMillan & Skinner 110, Maple lake.

VIOLACEÆ.

Viola obliqua Hill, Hort. Kew. 316. *pl. 12.* 1769.
Coll.: Ballard 2516, Fergus Falls; MacMillan & Skinner 382, Holmes.

Viola pedata L. Sp. Pl. 933. 1753.
Coll.: MacMillan & Skinner 279, Ives.

Viola canadensis L. Sp. Pl. 936. 1753.
Coll.: MacMillan & Skinner 351, Crookston.

ELÆAGNACEÆ.

Elæagnus argentea Pursh, Fl. Am. Sept. 114. 1814.
Coll.: Ballard 2578, Humboldt; 2801, Warren; MacMillan & Skinner 53, Crookston.

ONAGRACEÆ.

Epilobium lineare Muhl. Cat. 39. 1813.
Coll.: MacMillan & Skinner 292, Crookston.

Epilobium coloratum Muhl.; Willd. Enum. 1: 411. 1809.
Coll.: MacMillan & Skinner 115, Dugdale; 116, Maple lake; 244, Red Lake Falls; Ballard 2533, Fergus Falls; 2631, St. Vincent; 2742, Hallock.

Onagra biennis (L.) Scop. Fl. Carn. Ed. 2, 1: 269. 1772.
Coll.: MacMillan & Skinner 42, Crookston.

Œnothera rhombipetala Nutt.; T. & G. Fl. N. A. 1: 493. 1840.
Coll.: Ballard 2749, Hallock.

Anogra pallida (Lindl.) Britton, Mem. Torr. Club, 5: 234. 1894.
Coll.: MacMillan & Skinner 364, Crookston.

Meriolix serrulata (Nutt.) Walp. Repert. 2: 79. 1843.
Coll.: MacMillan & Skinner 33, Crookston; 109, Mentor.

Gaura coccinea Pursh, Fl. Am. Sept. 733. 1814.
Coll.: MacMillan & Skinner 430, Holmes.

HALORAGIDACEÆ.

Hippuris vulgaris L. Sp. Pl. 4. 1753.
Coll.: MacMillan & Skinner 230, Crookston.

Myriophyllum spicatum L. Sp. Pl. 992. 1753.
Coll.: MacMillan & Skinner 393, Holmes.

Myriophyllum verticillatum L. Sp. Pl. 992. 1753.
Coll.: Ballard 2653, St. Vincent.

ARALIACEÆ.

Aralia nudicaulis L. Sp. Pl. 274. 1753.
Coll.: MacMillan & Skinner 211, Crookston.

UMBELLIFERÆ.

Heracleum lanatum Michx. Fl. Bor. Am. **1**: 166. 1803.
Coll.: MacMillan & Skinner 202, Crookston.

Pastinaca sativa L. Sp. Pl. 262. 1753.
Coll.: Ballard 2662, St. Vincent.

Washingtonia longistylis (Torr.) Britton, Ill. Fl. **2**: 530. 1897.
Coll.: MacMillan & Skinner 238, Gentilly.

Sium cicutæfolium Gmel. Syst. **2**: 482. 1791.
Coll.: Ballard 2593, Humboldt.

Zizia aurea (L.) Koch, Nov. Act. Caes. Leop. Acad. **12**: 129. 1824.
Coll. MacMillan & Skinner 164, Maple lake; 206, 327, Crookston.

Zizia cordata (Walt.) Koch in DC. Prodr. **4**: 100. 1830.
Coll.: MacMillan & Skinner 253, Red Lake Falls.

Cicuta bulbifera L. Sp. Pl. 255. 1753.
Coll.: MacMillan & Skinner 183, Maple lake.

Deringa canadensis (L.) Kuntze, Rev. Gen. Pl. **1**: 266. 1891.
Coll.: MacMillan & Skinner 208, 325, 326, Crookston.

CORNACEÆ.

Cornus stolonifera Michx. Fl. Bor. Am. **1**: 92. 1803.
Coll.: MacMillan & Skinner 316, Crookston.

Cornus candidissima Marsh, Arb. Am. 35. 1785.
Coll.: Ballard 2752, Hallock; MacMillan & Skinner 242, Red Lake Falls.

ERICACEÆ.

Arctostaphylos uva-ursi (L.) Spreng. Syst. **2**: 287. 1825.
Coll.: MacMillan & Skinner 144, Maple lake.

VACCINIACEÆ.

Oxycoccus oxycoccus (L.) MacM. Bull. Torr. Club, **19**: 15. 1892.
Coll.: MacMillan & Skinner 185, Maple lake.

PRIMULACEÆ.

Steironema ciliatum (L.) Raf. Ann. Gen. Phys. **7**: 192. 1820.
Coll.: Ballard 2776, Warren; MacMillan & Skinner 16, Crookston.

Steironema lanceolata (Walt.) A. Gray, Proc. Am. Acad. **12**: 63. 1876.
Coll.: MacMillan & Skinner 98, Maple lake; 345, Crookston.

GENTIANACEÆ.

Gentiana detonsa Rottb. Act. Hafn. **10**: 254. 1770.
Coll.: MacMillan & Skinner 184, Maple lake.

Gentiana acuta Michx. Fl. Bor. Am. **1**: 177. 1803.
Coll.: MacMillan & Skinner 330, 346, Crookston.
No previous collections from Minnesota in the Herbarium of the University.

Gentiana puberula Michx. Fl. Bor. Am. **1**: 176. 1803.
Coll.: MacMillan & Skinner 54, Crookston; 350 Shirley.

Gentiana andrewsii Griseb. in Hook. Fl. Bor. Am. **2**: 55. 1834.
Coll.: Ballard 2792, Warren; MacMillan & Skinner 181, Maple lake.

Gentiana flavida A. Gray, Am. Journ. Sci. (II) **1**: 80. 1846.
Coll.: MacMillan & Skinner 81, Dugdale.

APOCYNACEÆ.

Apocynum androsæmifolium L. Sp. Pl. 213. 1753.
Coll.: MacMillan & Skinner 179, Maple lake.

ASCLEPIADACEÆ.

Asclepias incarnata L. Sp. Pl. 215. 1753.
Coll.: MacMillan & Skinner 29, Crookston; 399, Holmes.

Asclepias syriaca L. Sp. Pl. 214. 1753.
Coll.: MacMillan & Skinner 198, Crookston.

Asclepias speciosa TORR. Ann. Lyc. N. Y. **2**: 218. 1826.
Coll.: MacMillan & Skinner 58, Crookston.

CONVOLVULACEÆ.

Convolvulus sepium L. Sp. Pl. 153. 1753.
Coll.: Ballard 2566, St. Vincent; MacMillan & Skinner 403, Crookston.

CUSCUTACEÆ.

Cuscuta polygonorum ENGELM. Am. Journ. Sci. **43**: 342. 1842.
Coll.: Ballard 2674, St. Vincent.

Cuscuta gronovii WILLD.; R. & S. Syst. **6**: 205. 1820.
Coll.: MacMillan and Skinner 223, Crookston; 268, Thief River Falls; 376, Holmes.

BORAGINACEÆ.

Lappula lappula (L.) KARST. Deutsch. Fl. 979. 1880–83.
Coll.: Ballard 2770, Hallock; MacMillan & Skinner 245, Red Lake Falls.

Lappula americana (A. GRAY) RYDBERG, Bull. Torr. Club, **24**: 294. 1897.
Coll.: MacMillan & Skinner 243, Red Lake Falls.
No previous authentic collection reported from Minnesota. Previous collections of this species in this State have been made and determined as *L. floribunda* (Lehm.) Greene.

Onosmodium carolinianum (LAM.) DC. Prodr. **10**: 70. 1846.
Coll.: MacMillan & Skinner 386, Holmes.

VERBENACEÆ.

Verbena hastata L. Sp. Pl. 20. 1753.
Coll.: Ballard 2502, Fergus Falls; 2647, St. Vincent; MacMillan & Skinner 30, Crookston.

LABIATÆ.

Teucrium canadense L. Sp. Pl. 564. 1763.
Coll.: MacMillan & Skinner 118, Maple lake.

Scutellaria lateriflora L. Sp. Pl. 598. 1753.
Coll.: Ballard 2506, Fergus Falls; MacMillan & Skinner 1, Crookston.

Scutellaria galericulata L. Sp. Pl. 509. 1753.
Coll.: MacMillan & Skinner 302, Maple lake.

Agastache anethiodora (NUTT.) BRITTON, in Britton & Brown, Ill. Fl. **3**: 85. 1898.

Dracocephalum parviflorum NUTT. Gen. **2**: 35. 1818.
Coll.: Ballard 2556, St. Vincent; MacMillan & Skinner 284 Thief River Falls.

Physostegia virginiana (L.) BENTH. Lab. Gen. & Sp. 504. 1834.
Coll.: Ballard 2564, St. Vincent; 2766, Hallock; 2773, Warren; MacMillan & Skinner 21, 215, Crookston.

Galeopsis tetrahit L. Sp. Pl. 579. 1753.
Coll.: Ballard 2607, Humboldt.

Stachys palustris L. Sp. Pl. 580. 1753.
Coll.: Ballard 2640, 2650, St. Vincent; MacMillan & Skinner 232, Crookston.

Monarda fistulosa L. Sp. Pl. 22. 1753.
Coll.: MacMillan & Skinner 248, Red Lake Falls.

Koellia flexuosa (WALT.) MACM. Met. Minn. Val. 452. 1892.
Coll.: MacMillan & Skinner 96, Mentor.

Lycopus virginicus L. Sp. Pl. 21. 1753.
Coll.: MacMillan & Skinner 161, Maple lake.

Lycopus americanus MUHL.; Bart. Fl. Phil. Prodr. 15. 1815.
Coll.: Ballard 2648, St. Vincent; 2737, Hallock.

Lycopus lucidus TURCZ.; Benth. in DC. Prodr. **12**: 178. 1848.
Coll.: Ballard 2509, Fergus Falls.

Mentha canadensis L. Sp. Pl. 577. 1753.
Coll.: Ballard 2560, St. Vincent; 2592, Humboldt; MacMillan & Skinner 4, 426, Crookston.

SOLANACEÆ.

Solanum nigrum L. Sp. Pl. 186. 1753.
Coll.: MacMillan & Skinner 201, Crookston.

SCROPHULARIACEÆ.

Pentstemon gracilis NUTT. Gen. **2**: 52. 1818.
Coll.: MacMillan & Skinner 80, Maple lake.

Mimulus ringens L. Sp. Pl. 634. 1753.
Coll.: MacMillan & Skinner 224, Crookston.

Veronica americana SCHWEIN. Benth. in DC. Prodr. **10**: 468. 1846.
Coll.: Ballard 2744, Hallock.

Veronica scutellata L. Sp. Pl. 12. 1753.
Coll.: MacMillan & Skinner 395, Holmes.

Leptandra virginica (L.) NUTT. Gen. **1**: 7. 1818.
Coll.: MacMillan & Skinner 15, Crookston.

Gerardia aspera DOUGL.; Benth. in DC. Prodr. **10**: 517. 1846.
Coll.: MacMillan & Skinner 36, Crookston.

Gerardia tenuifolia VAHL, Symb. Bot. **3**: 79. 1794.
Coll.: Ballard 2510, 2536, Fergus Falls; 2748, Hallock; MacMillan & Skinner 277, Ives.

Orthocarpus luteus NUTT. Gen. **2**: 57. 1818.
Coll.: Ballard 2688, Northcote; 2719, Kennedy; MacMillan & Skinner 47, Crookston.

Pedicularis lanceolata MICHX. Fl. Bor. Am. **2**: 18. 1803.
Coll.: MacMillan & Skinner 93, Maple lake; 379, Holmes.

PHRYMACEÆ.

Phryma leptostachya L. Sp. Pl. 601. 1753.
Coll.: MacMillan & Skinner 240, Gentilly; 241, Red Lake Falls.

Plantago major L. Sp. Pl. 112. 1753.
Coll.: Ballard 2535, Fergus Falls; 2667, St. Vincent.

Plantago eriopoda TORR. Ann. Lyc. N. Y. **2**: 237. 1827.
Coll.: Ballard 2789, Warren.

RUBIACEÆ.

Houstonia longifolia GAERTN. Fruct. **1**: 226. 1788.
Coll.: MacMillan & Skinner 274, St. Hilaire.

Galium boreale L. Sp. Pl. 108. 1753.
Coll.: MacMillan & Skinner 289, Maple lake.

Galium trifidum L. Sp. Pl. 105. 1753.
Coll.: Ballard 2646, St. Vincent; MacMillan & Skinner 314, Crookston.

CAPRIFOLIACEÆ.

Viburnum opulus L. Sp. Pl. 268. 1753.
Coll.: MacMillan & Skinner 180, Maple lake.

Viburnum lentago L. Sp. Pl. 268. 1753.
Coll.: MacMillan & Skinner 272, Thief River Falls, 317, Crookston.

Symphoricarpos occidentalis Hook. Fl. Bor. Am. **1**: 285. 1833.
Coll.: Ballard 2750, Hallock; MacMillan & Skinner 20, Crookston.

Symphoricarpos symphoricarpos (L.) MACM. Bull. Torr. Club, **19**: 15. 1892.
Coll.: Ballard 2550, St. Vincent.

CUCURBITACEÆ.

Micrampelis lobata (MICHX.) GREENE, Pittonia, **2**: 128. 1890.

CAMPANULACEÆ.

Campanula rotundifolia L. Sp. Pl. 163. 1753.
Coll.: MacMillan & Skinner 236, Gentilly.

Campanula aparinoides PURSH, Fl. Am. Sept. 159. 1814.
Coll.: MacMillan & Skinner 163, Maple lake; 383, Holmes.

Lobelia syphilitica L. Sp. Pl. 931. 1753.
Coll.: Ballard 2503, Fergus Falls; MacMillan & Skinner 299, Crookston.

Lobelia spicata LAM. Encycl. **3**: 587. 1789.
Coll.: MacMillan & Skinner 57, 297, 298, Crookston.

Lobelia kalmii L. Sp. Pl. 930. 1753.
Coll.: MacMillan & Skinner 296, Maple lake.

CICHORIACEÆ.

Taraxacum taraxacum (L.) KARST. Deutsch. Fl. 1138. 1880–83.
Coll.: Ballard 2669, St. Vincent; MacMillan & Skinner 413, Crookston.

Sonchus arvensis L. Sp. Pl. 793. 1753.
Coll.: Ballard 2596, Humboldt.

Sonchus asper (L.) ALL. Fl. Ped. **1**: 222. 1785.
Coll.: MacMillan & Skinner 177, Maple lake.

Lactuca ludoviciana (Nutt.) DC. Prodr. **7**: 141. 1838.
Coll.: MacMillan & Skinner 34, Crookston.

Lactuca pulchella (PURSH) DC. Prodr. 7: 134. 1838.
Coll.: Ballard 2547, St. Vincent; 2617, Humboldt; 2712, Northcote; 2723, Kennedy; MacMillan & Skinner 31, Crookston.

Agoseris glauca (PURSH) GREENE, Pittonia, 2: 176. 1891.
Coll.: Ballard 2735, Kennedy; 2791, Warren; MacMillan & Skinner 43, Crookston.

Hieracium canadense MICHX. Fl. Bor. Am. 2: 86. 1803.
Coll.: Ballard 2768, Hallock; 2799, Warren; MacMillan & Skinner 84, Dugdale; 114, Maple Lake.

Nabalus albus (L.) HOOK. Fl. Bor. Am. 1: 294. 1833.
Coll.: Ballard 2627, St. Vincent; 2781, Warren; MacMillan & Skinner 76, Dugdale.

Nabalus racemosus (MICHX.) DC. Prodr. 7: 242. 1838.
Coll.: Ballard 2559, St. Vincent; 2609, Humboldt; MacMillan & Skinner 59, Crookston; 263, St. Hilaire.

AMBROSIACEÆ.

Iva xanthifolia (FRESEN.) NUTT. Trans. Am. Phil. Soc. (II.) 7: 347. 1841.
Coll.: Ballard 2659, St. Vincent; 2716, Kennedy.

Ambrosia trifida L. Sp. Pl. 987. 1753.
Coll.: Ballard 2567, St. Vincent, 2704, Northcote.

Ambrosia artemisiæfolia L. Sp. Pl. 987. 1753.
Coll.: Ballard 2513, Fergus Falls.

Ambrosia psilostachya DC. Prodr. 5: 526. 1836.
Coll.: Ballard 2538, Fergus Falls; 2689, Northcote; 2790, Warren; MacMillan & Skinner 331, Crookston.

Xanthium canadense MILL. Gard. Dict. Ed. 8, no. 2. 1768.
Coll.: Ballard 2511, Fergus Falls; 2677, St. Vincent; 2764, Hallock; MacMillan & Skinner 217, Crookston.

COMPOSITÆ.

Vernonia fasciculata MICHX. Fl. Bor. Am. 2: 94. 1803.
Coll.: MacMillan & Skinner 50, Crookston.

Eupatorium maculatum L. Amœn. Acad. 4: 288. 1755.
Coll.: MacMillan & Skinner 121, Maple lake; 391, Holmes.

Eupatorium perfoliatum L. Sp. Pl. 838. 1753.
Coll.: Ballard 2522, Fergus Falls; MacMillan & Skinner 159, Maple lake.

Laciniaria punctata (HOOK.) KUNTZE, Rev. Gen. Pl. 349. 1891.
Coll.: MacMillan & Skinner 92, Dugdale.

Laciniari apycnostachya (MICHX.) KUNTZE, Rev. Gen. Pl. 349. 1891.
Coll.: MacMillan & Skinner 97, Maple lake.

Laciniaria scariosa (L.) HILL, Veg. Syst. 4: 49. 1762.
Coll.: Ballard 2797, Warren; MacMillan & Skinner 61, 220, Crookston.

Grindelia squarrosa (PURSH) DUNAL in DC. Prodr. 5: 315. 1836.
Coll.: Ballard 2554, St. Vincent; 2700, Northcote; 2730, Kennedy; MacMillan & Skinner 88, Dugdale.

Chrysopsis hispida (HOOK.) NUTT. Trans. Am. Phil. Soc. (II.) 7: 316. 1841.
Coll.: MacMillan & Skinner 83, Dugdale; 388, Holmes.
Not previously reported from Minnesota.

Solidago canadensis L. Sp. Pl. 878. 1753.
Coll.: Ballard 2517, Fergus Falls; 2565, St. Vincent; 2711, Northcote; MacMillan & Skinner 303, Crookston; 397, Holmes.

Solidago nemoralis AIT. Hort. Kew. 3: 213. 1789.
Coll.: MacMillan & Skinner 342, 344, Crookston.

Solidago rigida L. Sp. Pl. 880. 1753.
Coll.: Ballard 2504, Fergus Falls; 2611, Humboldt; 2683, Northcote; 2731, Kennedy; 2795, Warren; MacMillan & Skinner 69, 339, Crookston.

Euthamia graminifolia (L.) NUTT. Gen. 2: 162. 1818.
Coll.: Ballard 2521, Fergus Falls; 2796, Warren.

Aster sagittifolius WILLD. Sp. Pl. 3: 2035. 1804.
Coll.: MacMillan & Skinner 25, Crookston; 256, St. Hilaire.

Aster novæ-angliæ L. Sp. Pl. 875. 1753.
Coll.: Ballard 2779, Warren; MacMillan & Skinner 78, Dugdale.

Aster puniceus L. Sp. Pl. 875. 1753.
Coll.: MacMillan & Skinner 287, Thief River Falls.

Aster lævis L. Sp. Pl. 876. 1753.
Coll.: MacMillan & Skinner 190, 196, 311, Crookston; Ballard 2518, Fergus Falls; 2561, 2622, St. Vincent; 2692, Northcote; 2738, Hallock.

Aster sericeus VENT. Hort. Cels. 1800.
Coll.: MacMillan & Skinner 82, Dugdale.

Aster ptarmicoides (NEES) T. & G. Fl. N. A. **2**: 160. 1841.
Coll.: MacMillan & Skinner 60, Crookston; 154, Maple lake; Ballard 2804, Warren.

Aster salicifolius LAM. Encycl. **1**: 306. 1783.
Coll.: Ballard 2785, Warren.

Aster paniculatus LAM. Encycl. **1**: 306. 1783.
Coll.: Ballard 2568, St. Vincent; 2674, Northcote; MacMillan & Skinner 312, Crookston.

Aster multiflorus AIT. Hort. Kew. **3**: 203. 1789.
Coll.: Ballard 2694, Northcote; 2724, Kennedy; 2802, Warren; MacMillan & Skinner, 336, Crookston.

Brachyactis angustus (LINDL.) BRITTON, in Britton & Brown, Ill. Fl. **3**: 383. 1898.
Coll.: Ballard 2545, Fergus Falls; 2784, Warren.

Erigeron philadelphicus L. Sp. Pl. 863. 1753.
Coll.: MacMillan & Skinner 226, 360, Crookston; Ballard 2649, St. Vincent.

Erigeron ramosus (WALT.) B.S.P. Prel. Cat. N. Y. 27. 1888.
Coll.: MacMillan & Skinner 44, Crookston; 95, Maple lake.

Leptilon canadense (L.) BRITTON, in Britton & Brown Ill. Fl. **3**: 391. 1898.
Coll.: Ballard 2633, St. Vincent; MacMillan & Skinner 37, Crookston.

Doellingeria umbellata pubens (A. GRAY) BRITTON, in Britton & Brown Ill. Fl. **3**: 393. 1898.
Coll.: MacMillan & Skinner 120, Maple lake.

Heliopsis scabra DUNAL, Mem. Mus. Paris, **5**: 56. 1819.
Coll.: MacMillan & Skinner 117, Maple lake; 204, Crookston.

Rudbeckia hirta L. Sp. Pl. 907. 1753.
Coll.: Ballard 2563, St. Vincent; MacMillan & Skinner 41, Crookston.

Rudbeckia laciniata L. Sp. Pl. 906. 1753.
Coll.: Ballard 2660, St. Vincent; MacMillan & Skinner 205, Crookston.

Ratibida columnaris (SIMS) D. DON; Sweet, Brit. Fl. Gard. **2**: 361. 1838.
Coll.: MacMillan & Skinner 75, Maple lake, 365, Holmes.

Helianthus annuus L. Sp. Pl. 904. 1753.
Coll.: Ballard 2675, St. Vincent.

Helianthus scaberrimus ELL. Bot. S. C. & Ga. **2**: 423. 1824.
Coll.: Ballard 2601, Humboldt; 2703, Northcote; 2739, Hallock; MacMillan & Skinner 333, Crookston; 367, Holmes.

Helianthus maximiliani SCHRAD. Ind. Sem. Hort. Goett. 1835.
Coll.: Ballard 2572, St. Vincent; 2696, Northcote; 2727, Kennedy; MacMillan & Skinner 352, 353, Shirley.

Helianthus grosse-serratus MARTENS, Sel. Sem. Hort. Loven. 1839.
Coll.: MacMillan & Skinner 295, 429, Crookston; 378, Holmes.

Helianthus tuberosus L. Sp. Pl. 905. 1753.
Coll.: MacMillan & Skinner 203, Crookston; 392, Holmes.

Bidens lævis (L.) B.S.P. Prel. Cat. N. Y. 29. 1888.
Coll.: MacMillan & Skinner 264, St. Hilaire; 362, Crookston; 371, Holmes.

Bidens cernua L. Sp. Pl. 832. 1753.
Coll.: MacMillan & Skinner 9, Crookston.

Bidens frondosa L. Sp. Pl. 832. 1753.
Coll.: Ballard 2623, Humboldt; 2678, St. Vincent; 2710, Northcote; 2733, Kennedy; 2763, Hallock; MacMillan & Skinner 11, 38, 207, Crookston.

Helenium autumnale pubescens (AIT.) BRITTON, Mem. Torr. Club, **5**: 339. 1894.
Coll.: MacMillan & Skinner 146, Maple lake.

Gaillardia aristata Pursh, Fl. Am. Sept. 573. 1814.
Coll.: MacMillan & Skinner 380, Holmes.
No previous authentic collections from Minnesota in the Herbarium of the University.

Achillæa millefolium L. Sp. Pl. 899. 1753.
Coll.: Ballard 2624, St. Vincent; MacMillan & Skinner 45, Crookston.

Artemisia caudata Michx. Fl. Bor. Am. 2: 129. 1803.
Coll.: MacMillan & Skinner 73, Crookston.

Artemisia dracunculoides Pursh, Fl. Am. Sept. 742. 1814.
Coll.: MacMillan & Skinner 65, Crookston.

Artemisia frigida Willd. Sp. Pl. 3: 1838. 1804.
Coll.: MacMillan & Skinner 74, Crookston; Ballard 2597, Humboldt.

Artemisia absinthium L. Sp. Pl. 848. 1753.
Coll.: Ballard 2553, St. Vincent.

Artemisia biennis Willd. Phytogr. 11. 1794.
Coll.: Ballard 2726, Kennedy.

Artemisia gnaphalodes Nutt. Gen. 2: 143. 1818.
Coll.: Ballard 2619, Humboldt; 2698, Northcote; 2732, Kennedy; 2798, Warren; MacMillan & Skinner 55, Crookston.

Arctium lappa L. Sp. Pl. 816. 1753.
Coll.: MacMillan & Skinner 210, Crookston.

Carduus altissimus L. Sp. Pl. 824. 1753.
Coll.: Ballard 2501, Fergus Falls; MacMillan & Skinner 170, Maple lake.

Carduus discolor (Muhl.) Nutt. Gen. 2: 130. 1818.
Coll.: MacMillan & Skinner 12, Crookston.

Carduus undulatus Nutt. Gen. 2: 130. 1818.
Coll.: MacMillan & Skinner 48, Crookston.

Carduus arvensis (L.) Robs. Brit. Fl. 163. 1777.
Coll.: Ballard 2548, St. Vincent; MacMillan & Skinner 283, Thief River Falls.

Explanation of Plate XXXIV.

General view of prairie near Shirley, Minn. This is the characteristic aspect of mesophytic prairie in the Red River valley. The shrubs are *Salix humilis*, for the most part. The herbs in the foreground are *Asters*. The view shows a minor tension line in which *Juncus dudleyi* is an abundant plant. On the right a growth of *Polygonum* intermixed with *Andropogon* is seen. The view gives an idea of the variety of the prairie vegetation.

Plate XXXV.

An island of *Hordeum* surrounded by a border zone of *Salix* intermingled with *Symphoricarpos* and *Solidago*. Such circular patches of squirrel-tail grass marking slight depressions in the prairie are not uncommon and often reach a considerable size, even covering several acres.

Plate XXXVI.

Prairie near Gentilly, Minn. In the background is seen the shrubby and scanty arboreal vegetation along the Red Lake river. In the middle distance a minor tension line of *Hordeum* is apparent extending, in this case, several miles along the river. In the foreground *Nabalus racemosus*, a characteristic wand plant of the region, is seen forming an almost circular patch in the general grass vegetation.

Plate XXXVII.

Gopher mound with characteristic vegetation. These mounds made by *Geomys bursarius* are abundant on the prairie throughout the district. Somewhat more xerophytic plants inhabit them than are found upon the level prairie where they occur. Upon this particular mound hazel-brush, *Artemisia*, *Bouteloua*, *Solidago rigida* and other semi-xerophytic or strongly xerophytic plants have secured a foothold.

Plate XXXVIII.

A growth of silver-berry—*Eleagnus argentea*. This plant is abundant throughout the district studied, in dry declivities or on slopes of the rolling prairie. It is also abundant in pastures along the Red Lake river.

Plate XXXIX.

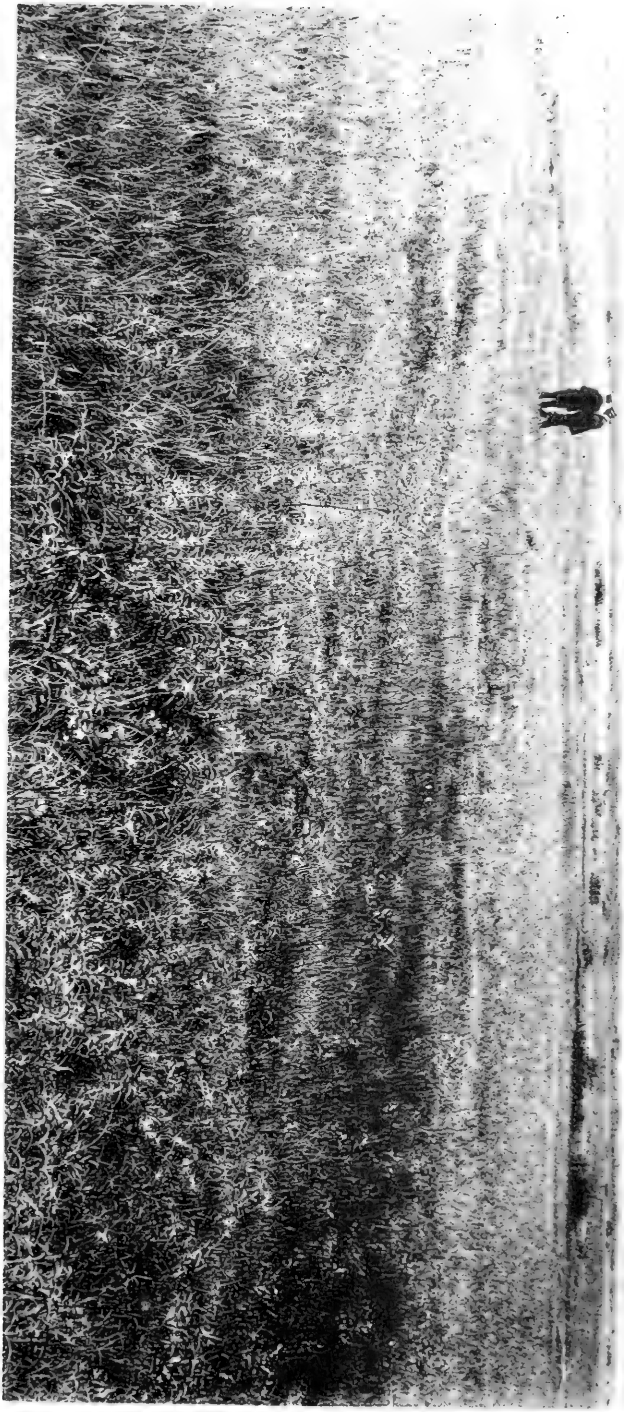
View of the margin of a grass meadow in the poplar scrub near Maple lake showing three stands of *Salix lucida*, a common plant of the tension zone between the meadow and the scrub.

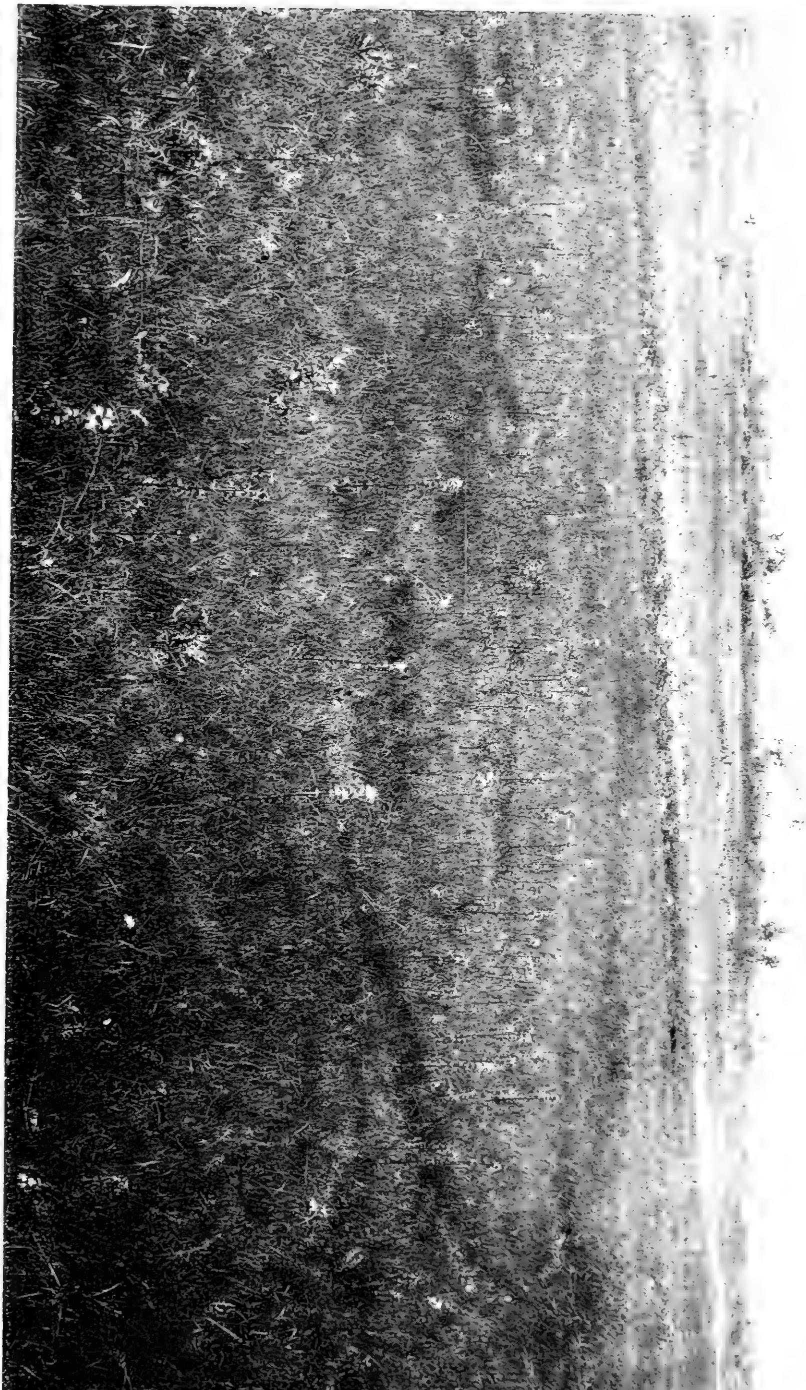
Plate XL.

View of xerophilous vegetation on knolls along a coulee cut in the raised beach of the extinct Lake Agassiz near Fertile, Minn. The brows of the knolls are occupied almost exclusively by an *Artemisia* formation in which three or four species are present, *Artemisia frigida* being the most abundant. Scrub poplars, hazel and *Quercus* form a sparse "gallery wood." On the upland *Gaillardia*, *Amorpha*, *Gaura* and other xerophytic herbs and shrubs of the prairie are abundant.

PLATE XLI.

Elm woods along the Red Lake river near Crookston, Minn. The bottoms being subject to overflow, show a scanty undergrowth mostly herbaceous, though with a few shrubs of *Ribes*, *Rubus* and *Corylus*. In such glades the bolls of the trees are commonly distorted and scarred owing to the battering which they receive when young by driftwood and flotsam during times of high water.





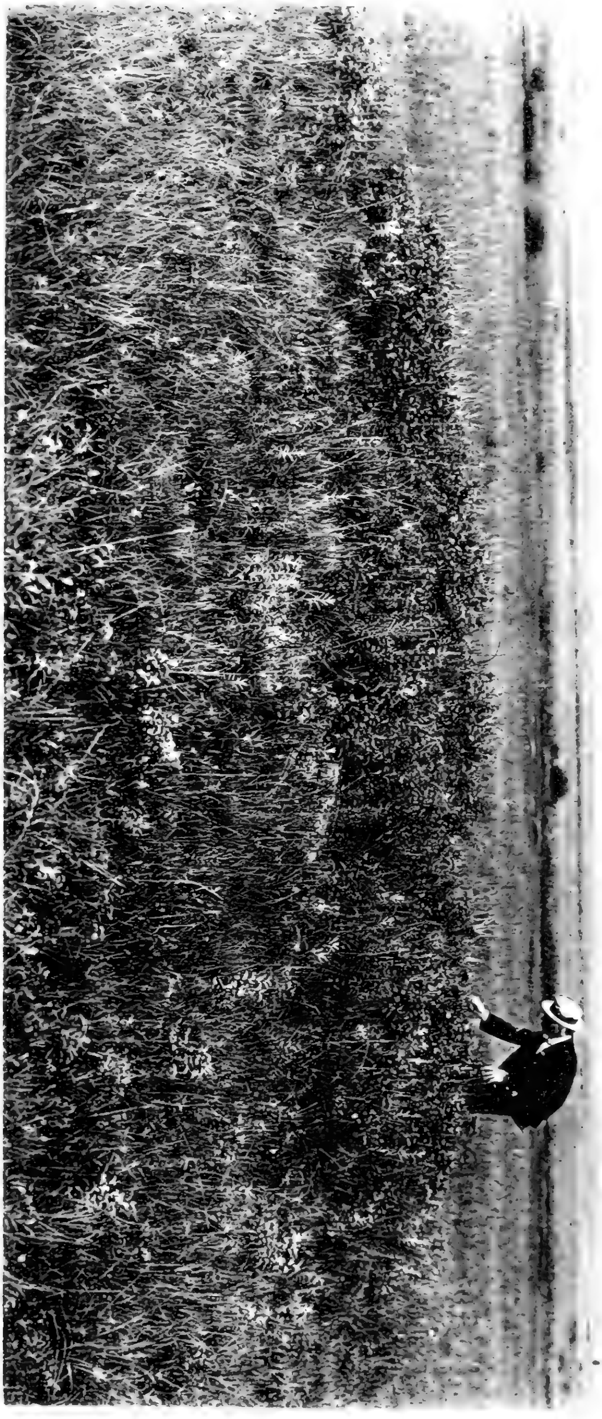
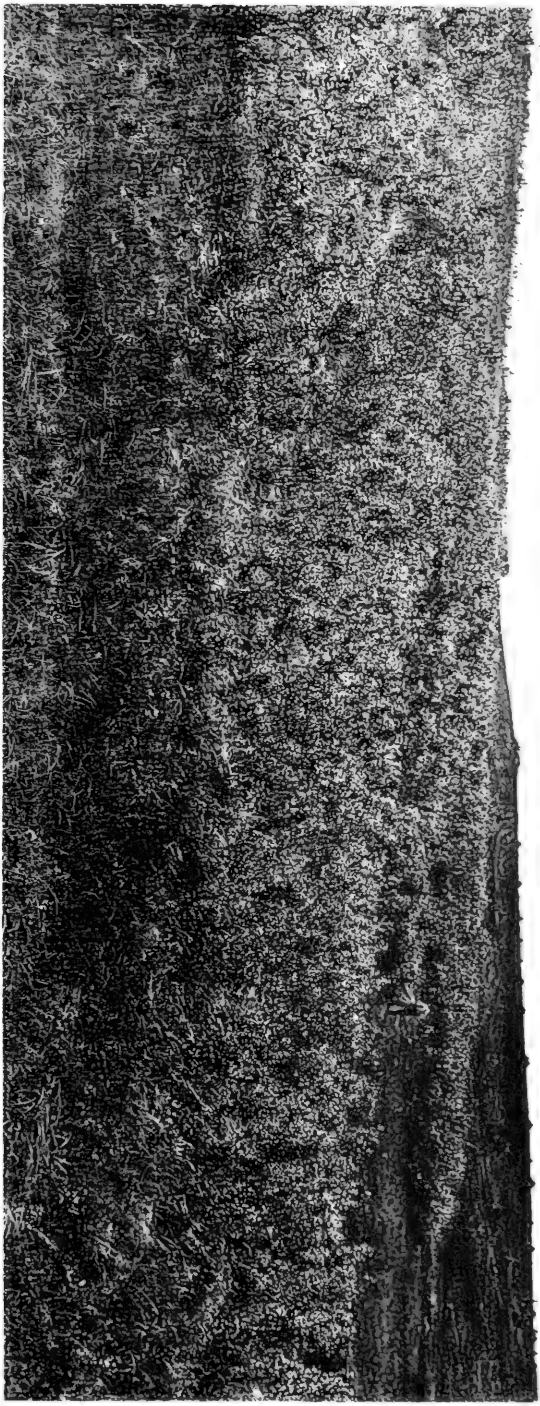


PLATE XXXVII

THE HELIOTYPE PRINTING CO., BOSTON



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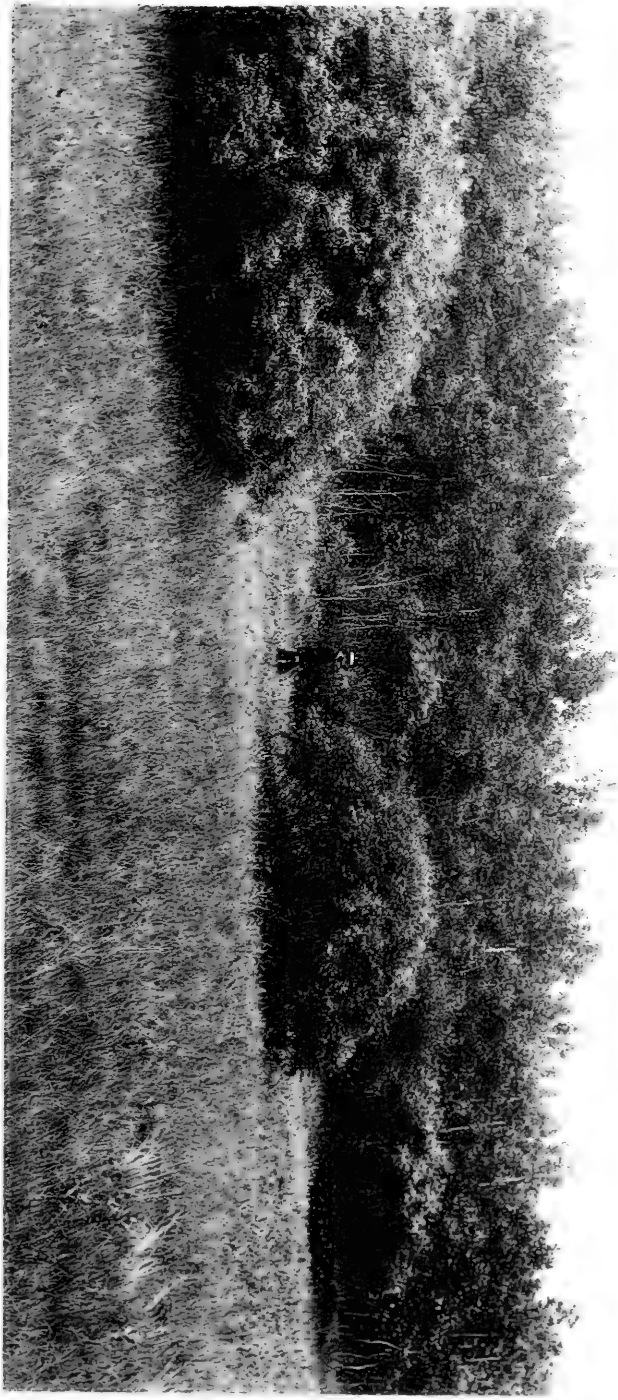

THE HELIOTYPE PRINTING CO., BOSTON

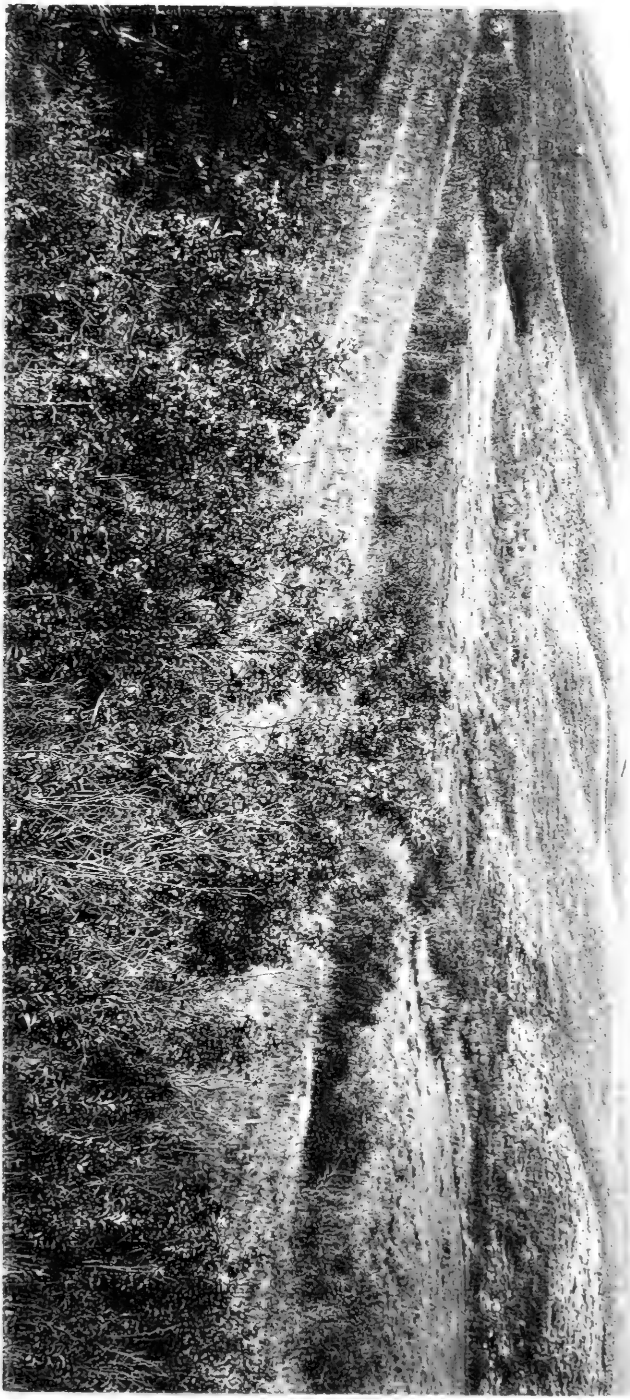

PLATE XII

THE HELIOTYPE PRINTING CO., BOSTON.

XXXIII. OBSERVATIONS ON *Gigartina exasperata* HARV.

H. B. HUMPHREY.

The plants used in the preparation of this paper were collected by Miss Josephine E. Tilden, in Puget Sound near Seattle, Washington, in August, 1897.

They are found growing at a depth of six fathoms though thriving in shallower water. In July, 1898, several plants were collected near Tracyton, Washington, at a depth of about four fathoms attached to rocks in quiet waters. These plants were generally large and well developed and were somewhat loosely attached to the substratum. Their position in the water was erect except in certain places where a tidal current was present. Plants found in localities washed by swift tidal currents were smaller, thicker and more firmly attached to the substratum.

The material was preserved in alcohol, consequently the plant could not be studied in its natural condition. All sections were cut by means of a freezing microtome. Material imbedded in gelatin when sectioned proved useless as the cells were swollen to such a degree as to appear unnatural. Portions of the frond were then sectioned directly from the alcoholic solution with good results.

The stains employed were Delafield's hæmatoxylin, methyl blue, methyl violet, iodine and fuchsin. Delafield's hæmatoxylin proved a good nuclear stain. Methyl blue was used in staining cell walls but was not as satisfactory as methyl violet. Iodine was used in staining carpospores and brings out very clearly the distinction between them and surrounding tissue. Fuchsin proved a very satisfactory stain used in connection with the study of protoplasmic pits, coloring them a deep red.

Sections were all treated with staining solution and then mounted directly in glycerine jelly, making a permanent mount.

Holdfast: The holdfast is a disc-shaped organ, exhibiting considerable variation in size. In the case of a single frond the holdfast is not much greater in diameter than the stipe immediately above. The under surface is smooth and somewhat flexible, though in comparison with other tissues it shows greater rigidity and strength. It is not unusual to find several fronds attached to one common holdfast which, upon close examination, presents the appearance of a compound organ, in some instances measuring nine mm. in diameter.

The tissue of the holdfast is unlike that of any other part of the plant. Pl. 42, Fig. 2, represents a longitudinal section through a portion of the holdfast showing distinctive areas from the point of attachment to the substratum to the tissue of the stipe. It was found that in removing the plant from its point of attachment the cuticle was removed from the holdfast leaving exposed those cells immediately adjacent, represented by (*a*). These cells appear to be somewhat irregular in outline, though generally quadrilateral, and are characterized by their exceedingly thick walls. Approaching the stipe these cells are slightly modified and in conjunction with them are found rather long somewhat egg-shaped cells, densely filled with contents. These cells, along with the others, are arranged approximately in rows extending vertically through the holdfast. Protoplasmic connection exists between all cells and the cell arrangement is so compact as to give great strength and rigidity to the tissue. These cells (Pl. 42, Fig. 2, *b*) are slightly modified and in conjunction with small, somewhat spherical cells closely attached and densely filled with granular contents. Abutting upon this area are the filamentous cells of the stipe, which are very similar to those found elsewhere in the frond.

Stipe.—In the early stages of the plant's growth the stipe is hardly to be distinguished from the lamina, but as the frond reaches maturity the stipe becomes a well-marked organ of deep red color. Immediately above the holdfast it is circular, but as it gradually merges into the lamina it loses its characteristic shape, becoming much expanded in one diameter and thinner in the other. The stipe seldom exceeds a length of 20 mm., while the diameter varies from 2 to 5 mm.

The stipe exhibits a structure similar to that of the lamina, though in the former the cells possess shorter diameters and the arrangement is more compact, thus affording greater rigidity and strength. The epidermal cells throughout the entire plant are enveloped by a firm cellulose sheath of variable thickness, from three to ten mic. (Pl. 42, Fig. 4, *a*.) This cuticle is somewhat elastic, smooth and highly transparent. Pl. 42, Fig. 5, *a* and *b*, represent surface views of a portion of the frond, showing epidermal cells as seen through the overlying cuticle. By focusing, deeper cells beneath the epidermal layer may be seen.

Beneath the epidermal cells and in connection with them are the pseudo-cortical cells, presenting an almost spherical outline and a somewhat loose though definite arrangement. These cells as well as the epidermal ones are densely filled with protoplasmic contents, though unlike the epidermal cells they contain no chromatophores.

The sections of the stipe were stained with an alcoholic solution of methyl blue which gave a very satisfactory cellulose reaction and revealed the fact that all the cells were imbedded in a dense gelatinous matrix between which and the cell walls it is not easy to distinguish.

Adjoining the pseudo-cortical cells and occupying the central region of the stipe is the pseudo-medullary area composed of irregular cells. Pl. 42, Fig. 3, and Pl. 42, Fig. 4, represent transverse and longitudinal sections of the stipe. In Pl. 42, Fig. 3, *c*, a network of somewhat filamentous cells is seen to be interwoven with other cells of different form forming altogether a rather loose arrangement.

Lamina.—The general shape of the lamina is almost invariably cuneate, attaining its greatest diameter a little way from the apex. In all cases the frond is flat and not greater than three mm. in thickness, and when dry is quite translucent.

It commonly grows from 30 to 50 cm. in length and from 6 to 18 cm. in width, thus showing considerable variation in size. In shape it is quite as variable; some fronds being branched profusely while others show little or no branching whatever.

New fronds arise from the base of the stipe forming at first somewhat club-shaped or pointed bodies, but later expand and assume the characteristic shape of the mature frond. (Pl. 42, Fig. 1.) Both sides of the frond, including the margin, are thickly studded with cystocarps and numerous epidermal proliferations. Near the base of the frond on each side is a small area totally void of proliferations. Here the frond is thicker than elsewhere, more deeply colored and possesses a glossy smoothness.

The cystocarps sometimes appear as surface elevations though commonly they are developed in the marginal and surface proliferations. They are most numerous and attain greatest size in the marginal area while at the center they are scattering and poorly developed, numbering from 8 to 10 per sq. cm. as compared with 15 to 18 near the margin.

The broad flat branches of the lamina, owing to extreme thinness and position, bear few cystocarps though the number of proliferations may be great.

The epidermal cells of the lamina are very similar in every respect to those of the stipe except that the arrangement is less compact. The same may be said regarding the pseudo-cortical area, but a difference is seen in the pseudo-medullary cells; these are all filamentous, densely filled with granular protoplasmic contents (Pl. 42, Figs. 6 and 7) and so joined as to form a complete network.

Through the use of certain staining reagents it was found that a protoplasmic connection existed between the several cells of the frond, best seen in the pseudo-medullary region of the lamina. (Pl. 42, Fig. 8.) On further examination, using alcoholic solution of fuchsin as a staining reagent, protoplasmic pits were seen to exist between the several cells. These pits were composed in every case of two minute callous plates which when stained were found to give a reaction similar to that of protoplasm. It was not possible to determine the function of these connections, but no doubt they serve as paths of communication between cells. In Schmitz's discussion of the protoplasmic pits he shows that they are traversed by plasma-cords which serve for conduction of dynamic influences from cell to cell. He believes a transfer of dissolved food material possible because of the pores in the pit, but does not regard as probable the transfer of protoplasm.

Proliferations and cystocarp.—Pl. 42, Fig. 9, represents an early stage in the development of a proliferation. Certain of the epidermal cells become slightly modified in shape, cell division takes place vertically and apparently transversely. This increase in the number of cells causes an elevation to develop and as it continues a well-developed proliferation eventually prevails which may or may not bear a cystocarp.

In the material at hand the writer was unable to secure any sections showing tetraspores.

The development of the cystocarp, however, was quite clearly brought out. As the proliferation advances in its development there arises an irregular cellular formation of gonimoblast filaments and sterile tissue in the interior of which groups of branched filaments develop the carpospores. This entire formation is surrounded by a definite area of cells forming the cystocarpic wall. As the cystocarp advances towards maturity a perforation occurs through the breaking down and gradual dissolution of certain cells, thus furnishing the mature spores an avenue of escape (Pl. 42, Fig. 11). The tissue of the proliferation surrounding the spore cavity is similar to that of the lamina proper, except that the cells are more compactly arranged.

Sections of this tissue were treated with Delafield's hæmatoxylin which proved to be a good nuclear stain revealing in several cells well-marked nuclei. (Pl. 42, Fig. 12.)

Several sections were made in order to determine the structure and characteristics of the mature cystocarp. Pl. 42, Fig. 13, represents such a cystocarp showing the spores arranged in groups surrounded by apparently empty filamentous cells, thus forming a compound cystocarp. Previous to the maturity of the spores they are all attached to the gonimoblastic filaments of which they were originally a part. They are evidently attached by means of protoplasmic threads, though no evidence of pits occurred. (Pl. 42, Fig. 15.) The carpospores, when mature, measure from 10 to 12 μ along one diameter and 11 to 13 μ along the other, while the cystocarp measures from two to three mm. in diameter through the conceptacle.

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Description of Plate XLII.

Figure 1. A typical frond of *Gigartina exasperata* one-fourth natural size.

Figure 2. Longitudinal section of holdfast. × 450.

Figure 3. Cross section of stipe. *a*, Epidermal cells; *b*, pseudo-cortical cells; c, pseudo-medullary cells. × 450.

Figure 4. Longitudinal section of stipe. *a*, Epidermal cellulose sheath. × 450.

Figure 5. (*a*) Surface view of frond, showing epidermal cells through the transparent epidermal sheath. (*b*) Surface view of frond showing cells beneath the epidermal cells. × 900.

Figure 6. Cross section of frond. × 450.

Figure 7. Filamentous cells of the pseudo-medullary area showing granular contents. × 900.

Figure 8. Protoplasmic connections between cells of pseudo-medullary area. × 900.

Figure 9. An early stage in development of a proliferation showing growing point (*a*). × 450.

Figure 10. A portion of the margin of a frond showing proliferations and cystocarps.

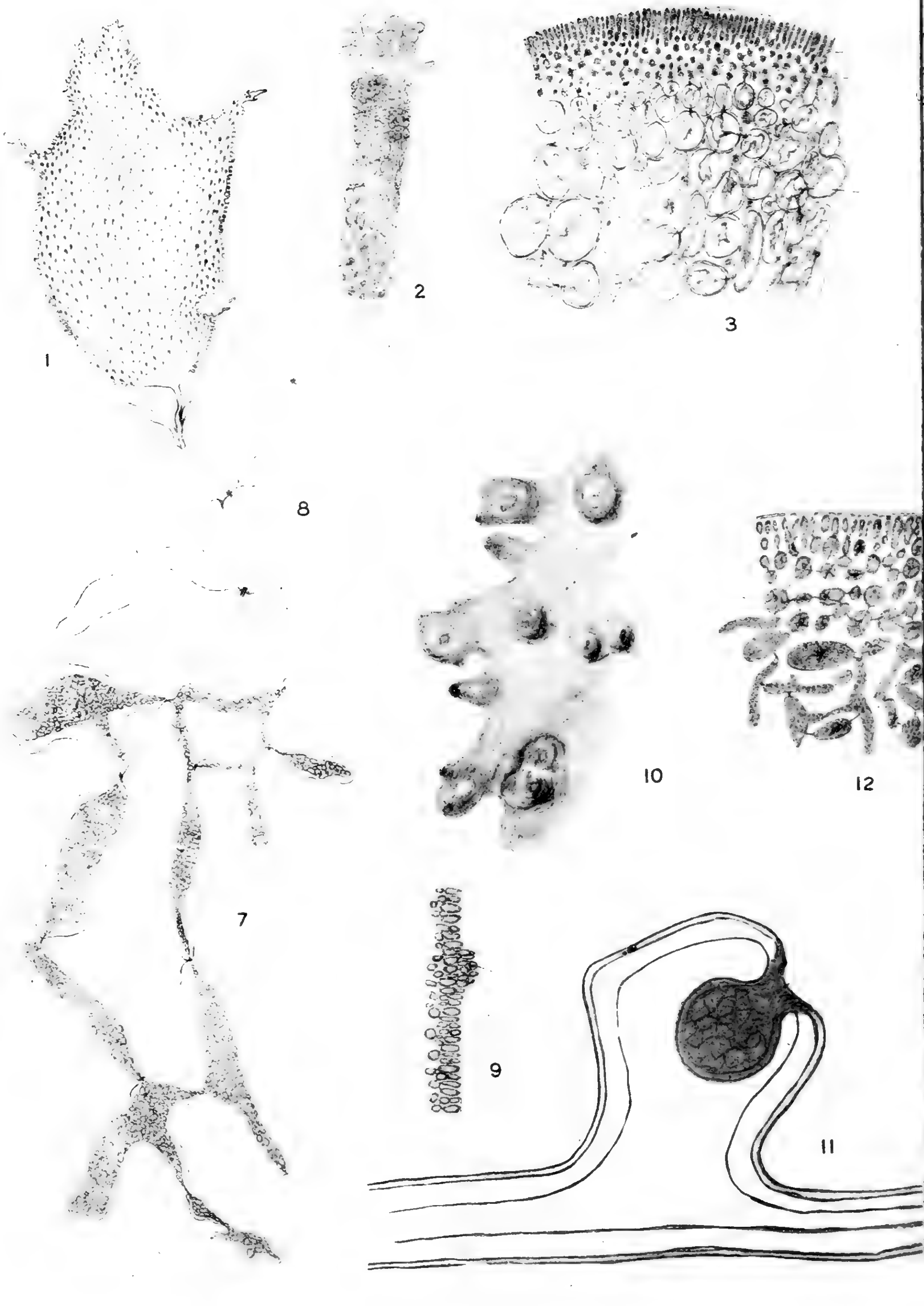
Figure 11. Longitudinal section of mature cystocarp. *O*, carpostome; *a*, conceptacle.

Figure 12. Portion of tissue surrounding a conceptacle showing cell nuclei. × 700.

Figure 13. Cross section of mature cystocarp showing spores.

Figure 14. Two groups of spores separated by elongated sterile cells. × 150.

Figure 15. Immature carpospores still attached to the gonimoblastic filaments; (*a*) a spore separating from filaments. × 480.



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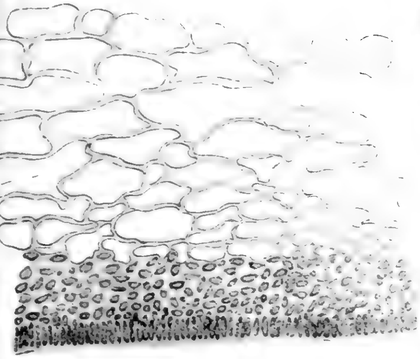

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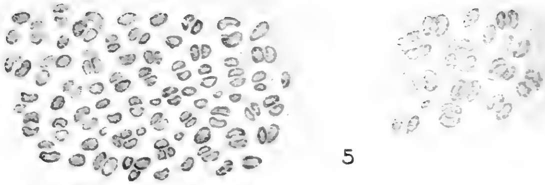

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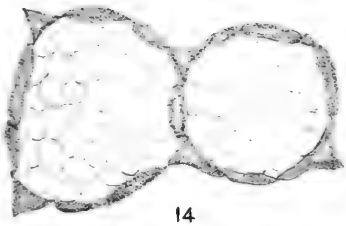

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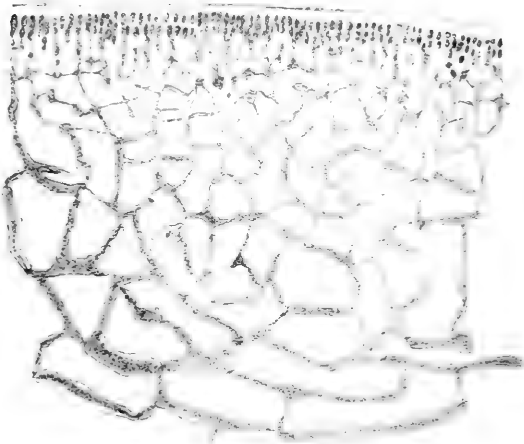

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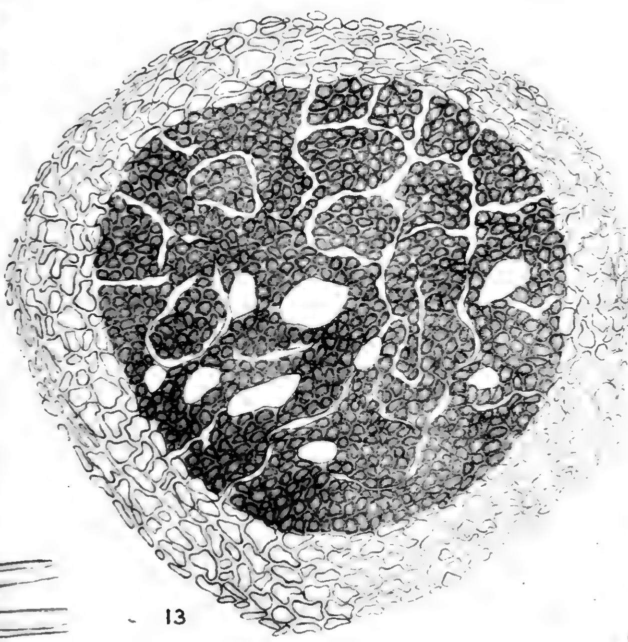

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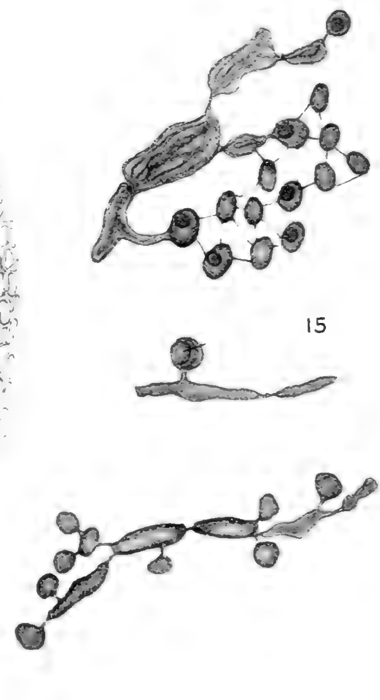

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E XLII.

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XXXIV. OBSERVATIONS ON THE ALGÆ OF THE ST. PAUL CITY WATER.

M. G. Fanning.

St. Paul receives its water supply from twenty-two lakes north of the city which are situated on both sides of a divide or watershed. The area from which the water is received extends about twenty miles north of the city. The greater part of the water comes immediately from Lake Vadnais, which in return receives its supply from chains of lakes through brooks, artificial canals, conduits, etc. As these lakes are separated by a divide pumping stations are provided at Centreville lake and Baldwin's lake to force the water over the divide. Besides the lakes, groups of artesian wells add to the supply and help to lower the temperature of the water during the summer months. There are nine wells at Lake Vadnais and twenty-eight at Centreville lake, making thirty-seven in all with depths varying from sixty-three to eight hundred and sixty-five feet.

Pleasant lake receives the water from the north slope of the watershed; from here the water flows from Lake Vadnais, then it is conveyed four and one-half miles through a conduit to the pumping station. The elevated portions of the city receive the water directly from the pumping station. Other parts are supplied by gravity with water from Lakes Gervais and Phalen. In order to get sufficient pressure to supply the higher areas, the water is forced into a reservoir one mile west of the pumping station. This reservoir is 290 feet above the water level of the Mississippi river and has a capacity of 18,000,000 gallons. There is another reservoir on the West Side to supply the elevated district across the river.

At the pumping station and also at the entrance of the conduit leading from Lake Vadnais, a series of graduated wire screens strain from the water the coarser vegetable growth.

Method of collection.—The method of collection is practically the one suggested by Dr. Smith Ely Jelliffe * and is as follows: A piece of absorbent cotton four or five inches square and one inch thick is attached by means of a twelve-inch square of unbleached muslin to the water faucet. The water is then turned on sufficiently to insure a constant stream and is allowed to run from ten to twelve hours, after which the cotton is removed. The cotton, which is usually quite brown from the organisms, is divided into pieces and rubbed and rinsed in five beakers each containing 200 c.c. of water. The water is then poured into one vessel and allowed to settle, after which the deposit is put into a glass containing 25 c.c. A few drops of this is transferred to a slide by means of a pipette and examined microscopically. At least ten mounts from each week's collection of material was examined in this way. The rest was then preserved in 2 per cent. formaline for future reference.

For the records, Dr. Jelliffe's method of computation was adopted. In computing the numbers the following schedule was used:

Abundant,	25 + in one c.c. of water.
Common,	10–25 in one c.c. of water.
Few,	5–10 in one c.c. of water.
Scarce,	1–5 in one c.c. of water.
Present,	Less than five in one c.c. of water.

Since November, 1899, weekly collections have been made of the plant life in the St. Paul water supply and the organisms identified (as far as possible) and their number computed.

The vegetable organisms found were all algæ if we except the pollen grains and Fungi spores that appeared occasionally. The Algæ found were as follows:

1.	*Diatomaceæ*,	13 varieties.
2.	*Cyanophyceæ*,	11 varieties.
3.	*Chlorophyceæ*,	32 varieties.
4.	*Peridiniæ*,	2 varieties.

Of these some forms of Diatoms were present almost constantly, especially *Melosira*, *Stephanodiscus*, two varieties of

* Jelliffe, S. E. A preliminary report upon the microscopical organisms found in the Brooklyn water supply. Brooklyn Med. Journ. 7: 595. O. 1893.

Synedra and *Asterionella*. Of the Chlorophyceæ, *Scenedesmus* and *Raphidium* were present most of the time. Among the Cyanophyceæ, *Oscillatoria* and *Cœlosphærium* were practically constant.

The effect of the cold on some of the varieties is shown by the accompanying plates (Pl. XLIII. and XLIV.). It will be seen that a fall in temperature coincides with a decrease in the numbers of all except *Oscillatoria*, which shows a gradual increase with the cold and is abundant for several weeks during the severest weather.

The desmids, more plentiful in the fall than at any other time, although never abundant, disappeared after the cold wave of the third week in December. Another fall in temperature about the fourth week in January banished most of the Chlorophyceæ and cleared the field of *Cœlosphærium*, but some of the diatoms persisted until the zero weather in February, when most of them disappeared. *Fragilaria* was abundant in January and about January 30th, when *Oscillatoria* and *Fragilaria* were practically the only forms seen, the water contained considerable sandy débris and entangled in it were quantities of resting spores of *Glœotrichia*.

The observations vary from year to year so that a record should be kept for several years before one could find what forms were both constant and abundant. For example, in the fall of 1898, *Anabæna* was "common," but in the following year it is only marked "present."

I wish to thank Mr. P. F. Lyons, of the St. Paul Weather Bureau and Mr. John Caulfield, Secretary of the Water Board, St. Paul, for their kind assistance.

Explanation of Plates XLIII. and XLIV.

Table showing relation between abundance of certain forms and temperature. XLIV. is a continuation of XLIII.

Plate XLV.

1. *Cœlastrum microporum* Naeg. var. *speciosum* Wolle. Freshw. Algae U. S. 170. *pl. 156. f. 4.* 1887.

2. *Pediastrum duplex* Meyen Beob. über Algenformen. in Nova Acta Acad. Leop. Carol. 772. 1829.

3. *Scenedesmus quadricauda* (Turp.) Bréb. Alg. Falais. 66. 1835.

4. *Scenedesmus bijugatus* (Turp.) Kg. Syn. Diat. 607. 1833.

5. *Rhaphidium polymorphum* Fresen. var. *aciculare* (A. Br.) Rabenh. Fl. Eur. Algar. **3**: 45. 1868.

6. *Rhaphidium polymorphum* Fresen. var. *falcatum* (Corda) Rabenh. Fl. Eur. Algar. **3**: 45. 1868.

7. *Nephrocytium agardhianum* Naeg. Gatt. einz. Alg. 80. *pl. 3 C.* 1849.

8. *Dictyosphærium pulchellum* Wood. Freshw. Algæ U. S. 84. 1873.

9. *Eudorina elegans* Ehrenb. in Monatsb. der Akad. d. wiss. zu Berlin. 78, 152. *pl. 2. f. 10.* 1831.

10. *Pandorina morum* (Muell.?) Bory in Ehrenb. Infus. 53. *pl. 2. f. 33.* 1838.

11. *Glœocystis gigas* (Kg.) Lagerh. Bidrag. till Sveriges Algfl. 63. 1883.

12. *Micrasterias truncata* (Corda) Bréb. in Ralfs Brit. Desmid. 75. no. 9. *pl. 8. f. 4.* and *pl. 10. f. 5.* 1848.

13. *Staurastrum sebaldi* Reinsch. Algenf. von Franken. 175. *pl. 11. f. 1.* 1867.

14. *Staurastrum minneapoliense* Wolle in Bull. Torr. Bot. Club, **12**: 5. *pl. 47. f. 11–13.* 1885.

15. *Staurastrum paradoxum* Meyen. var. *longipes* Nordst. Sydlig. Norg. Desm. 35. *f. 17.* 1873.

16. *Arthrodesmus incrassatus* Lagerh. var. *cycladatus* Lagerh. Bidrag till Amer. Desm.-Flora. 242. *pl. 27. f. 19.* 1885.

17. *Pleurotæniopsis quaternaria* (Nordst.) De Toni. Syll. Algar. **1**: 914. 1889.

18. *Cosmarium nitidulum* De Not. Element. 42. *pl. 3. f. 26.* 1867.

19. *Closterium parvulum* Naeg. Gatt. einz. Alg. 106. *pl. 6. C. f. 2.* 1849.

20. *Nostoc* sp. und.

21. *Anabæna flos-aquæ* (Lyngb.) Bréb. Algues des environs de Falaise 36. 1835.

22. *Lyngbya majuscula* Harv. in Hooker, Eng. Fl. **5**: 370. 1833.

23. *Merismopedia glauca* Naeg. Gatt. einz. Alg. 55. *pl. 1. D. f. 1.* 1849.

24. *Cœlosphærium kützingianum* Naeg. Gatt. einz. Alg. 54. *pl. 1. C.* 1849.

25. *Anacystis marginata* Menegh. Consp. 6. 1837.

26. *Peridinium tabulatum* Ehr. in Kent. Manual of the Infusoria. 1: 448.

Plate XLVI.

1. *Amphora ovalis* (Bréb.) Kg. Bac. 107. *pl. 5. f. 35, 39.* 1844.

2. *Cymbella lanceolata* (Ehr.) Kirchn. Alg. Schles. 188. 1878.

3. *Asterionella formosa* Hass. in Micr. Exam. 10.

4. *Synedra ulna* (Nitzsch.) Ehr. Infus. 211. *pl. 17. f. 1.* 1836.

5. *Synedra pulchella* (Ralfs.) Kg. Bacill. 68. *pl. 29. f. 37.* 1844.

6. *Fragilaria capucina* Desmaz. Crypt. de France (ed. 1), no. 453. 1825.

7. *Tabellaria fenestrata* Lyngb. Kg. var. *intermedia* Grün. in., V. H. Syn. *pl. 52. f. 6–8.* 1880–81.

8. *Cyclotella comta* (Ehr.) Kg. Spec. Algar. 20. 1849.

9. *Stephanodiscus niagaræ* Ehr. in Berl. Akad. 80. 1845.

10. *Melosira granulata* (Ehr.) Ralfs. in Pritch. Inf. 820. 1845–61.

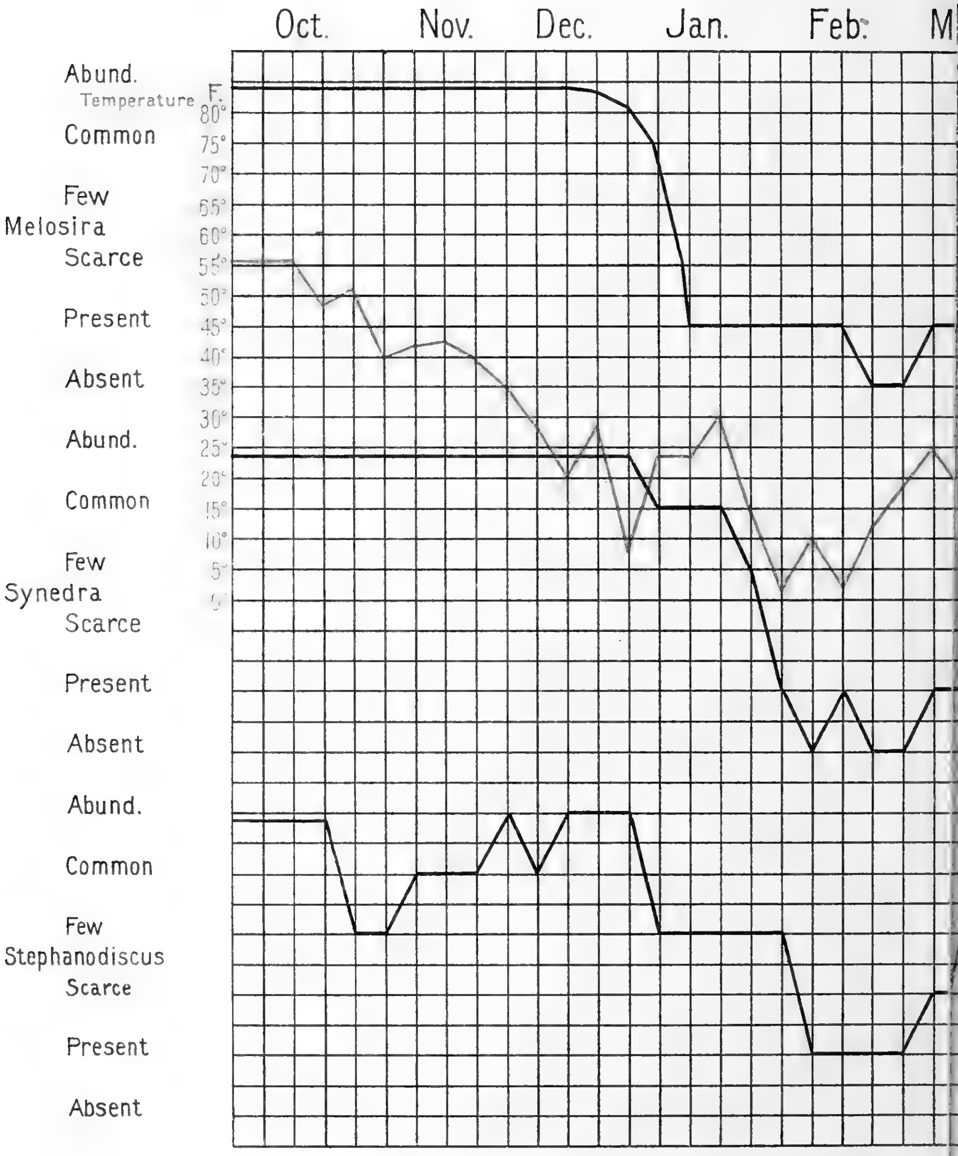
11. *Ceratium longicorne* Carter.

	November 7.	November 14.	November 21.	November 28	December 5.	December 12.	December 19.	December 26.	January 2.	January 9.	January 16.	January 23.	January 30.	February 6.	February 13.	February 20.	February 27.	March 6.	March 13.	March 20.	March 27.	April 3.	April 10.	April 17.	April 24.
CYANOPHYCEÆ.																									
1. Anacystis																									
2. Anabæna	sc	sc	pr	sc	pr	pr	pr	pr																	
3. Chroococcus														pr	pr		pr								
4. Clathrocystis																									
5. Cœlosphærium	c	c	c	fw	sc	fw	fw	pr	pr	pr	fw	sc				fw	c	c	c	c	c	sc	sc	sc	sc
6 Glœotrichia													ab												
7. Lyngbya																									
8. Merismopedia	ab	c	c	fw	fw	fw	pr			pr	pr						pr	pr	pr	pr					
9. Nostoc	pr	sc	pr																						
10. Oscillatoria	pr	sc	sc	fw	ab	c	c	c	c	ab	ab	ab	ab	ab	ab	c	c	c	c	c	fw	fw	ab	ab	ab
11. Phormidium										pr		pr	pr	pr	fw	fw	c	pr	pr						
DIATOMEÆ.																									
1. Amphora		pr					pr		pr				pr												
2. Asterionella	sc	sc	sc	sc	pr	pr	pr		p	pr	fw	fw	pr	pr			pr	pr	pr	c	c	c	fw	fw	pr
3. Cyclotella														pr		pr	pr	pr		pr			sc	sc	fw
4. Cymbella																					pr	pr			
5. Encyonema				pr																pr		pr			
6. Fragilaria																		pr		pr		pr	fw	sc	sc
7. Melosira	ab	ab	ab	ab	ab	ab	ab	ab	c	pr		pr	pr	pr	pr			pr	pr	pr	c	fw	fw	sc	sc
8. Navicula											fw														
9. Stephanodiscus	c	c	c	ab	c	ab	ab	ab	fw	c	c	fw	fw	pr	pr	pr	pr	sc	sc	c	c	c	sc	pr	pr
10. Synedra pulchella	ab	ab	ab	ab	ab	ab	ab	ab	c		fw	fw	pr		pr			pr	pr	pr	sc	fw	fw	fw	pr
11. " ulna	c	fw	c	c	fw	fw	fw	fw	pr	fw		fw	pr	pr	fw	sc	sc	fw	fw	fw	fw	fw	fw	fw	pr
12. Tabellaria fenestrata			pr		pr			pr	pr		fw	fw		pr	pr				fw	fw	fw	fw	sc	pr	pr
13. " flocculosa											fw	fw	pr		pr				pr	pr	pr	pr	sc	pr	fw
CHLOROPHYCEÆ.																									
1. Arthrodesmus																									
2. Botryococcus																									
3. Cerasterias																									
4. Cladophora																									
5. Closterium								pr			pr	pr		pr											
6. Cœlastrum	pr	pr		pr																					

	November 7.	November 14.	November 21.	November 28.	December 5.	December 12.	December 19.	December 26.	January 2.	January 9.	January 16.	January 23.	January 30.	February 6.	February 13.	February 20.	February 27.	March 6.	March 13.	March 20.	March 27.	April 3.	April 10.	April 17.	April 24.
7. Cosmarium		pr	pr			pr	pr		pr	pr															
8. Dictyosphærium	sc	fw	fw	fw	fw	c	fw	fw	pr	pr	fw		pr												
9. Dimorphococcus																									
10. Eudorina																									
11. Glœocystis																							pr	pr	pr
12. Micrasterias		pr		pr																					
13. Nephrocytium																							pr		pr
14. Pandorina	sc	sc	pr	pr																					
15. Pediastrum boryanum	pr	pr								pr	pr											pr			
16. " duplex	pr	pr	pr	pr			pr	pr					pr												
17. Pleurotæniopsis																									
18. Protococcus						pr												pr							
19. Raphidium polymorphum var. aciculare					pr				pr	pr	pr		pr					pr	pr						
20. Raphidium polymorphum var. falcatum	pr	pr	pr	pr	sc	pr	pr	fw	fw	fw	fw	c			pr	fw	c	c	c	c	c	fw	fw	c	fw
21. Raphidium polymorphum var. sigmoidea						pr	pr	pr	fw	fw	fw	fw	fw	pr			fw	c	c	c	c	c	c	fw	pr
22. Scenedesmus bijugatus																									
23. " quadricauda	ab	ab	ab	ab	ab	ab	ab	fw	pr	pr	c	c	sc	sc	sc	sc	sc	fw	c	c	c	c	c	c	fw
24. " obliquus	pr																								
25. Spirogyra	pr																								
26. Staurastrum crenulatum		pr		pr																					
27. " minneapoliense	pr																pr				pr				
28. " paradoxum																							pr		
29. " sebaldi	pr			pr																					
30. Stigeoclonium																									
31. Tetraspora																									
32. Volvox globata	pr	pr																		pr	pr	pr			
PERIDINEÆ.																									
1. Peridinium																		pr	pr		pr	sc	sc	sc	c
2. Ceratium tripos	pr	pr		pr	pr																				

	May 1.	May 8.	May 15.	May 22.	May 29.	June 5.	June 12.	June 19.	June 26.	July 3.	July 10.	July 17.	July 24.	July 31.	August 7.	August 14.	August 21.	August 28.	September 4.	September 11.	September 18.	September 25.	October 2.	October 9.	October 16.	October 23.	October 30.
CYANOPHYCEÆ.																											
1. Anacystis																				pr			pr				
2. Anabæna									pr	pr	pr	pr	pr		pr	sc	sc	fw	pr							pr	pr
3. Chroococcus		pr	pr	pr	pr	pr			pr	pr	pr	pr	pr		sc	sc	fw	fw	fw	pr							
4. Clathrocystis													pr		pr	pr	fw	fw	fw	fw	fw	fw	fw	sc	pr	pr	pr
5. Cœlosphærium	c	sc	fw	fw	c	c	c	c	c	c	c	c	fw		c	c	fw	c	c	ab	ab	ab	ab	ab	ab	ab	ab
6. Glœotrichia																											
7. Lyngbya		pr	pr	pr	pr	pr	fw	sc	sc	fw	sc	pr	pr		sc	sc	fw	fw	fw	ab	c	sc	pr	pr	pr		
8. Merismopedia																pr	pr		pr	pr		pr	pr	sc			
9. Nostoc								pr	sc	fw	fw	fw	sc		sc	fw	fw	fw	fw	fw	sc	sc	c	c	sc	sc	sc
10. Oscillatoria	c	fw	pr				pr		pr	pr		pr	pr			pr	pr	pr	pr	sc	sc	sc	c	c	sc	sc	sc
11. Phormidium						pr				pr		pr								pr	pr	pr					
DIATOMEÆ.																											
1. Amphora										pr	pr						pr			pr					pr		
2. Asterionella	fw	fw	fw	fw	sc		pr	pr				pr	pr							pr	pr	pr		pr	sc	fw	
3. Cyclotella	sc	c	sc	c	ab	ab		c	c	pr	pr	pr	pr		pr		pr			pr							
4. Cymbella																							pr				
5. Encyonema																											
6. Fragilaria			fw	fw	pr				pr	pr	pr	pr	pr									pr			pr		
7. Melosira	c	sc	sc	fw	fw	c	c	ab	ab	ab	c	c	sc		sc	sc	pr	pr	pr	sc	fw	c		ab	ab	ab	ab
8. Navicula																pr		pr									
9. Stephanodiscus	pr	pr	pr					pr	pr	pr	pr	pr						pr	pr	pr	pr	pr	pr	pr	pr	pr	pr
10. Synedra pulchella	c	c	c	c	c	sc	c	c	ab	ab	c	c	fw		fw	sc	pr		pr	pr	sc	c	ab	ab	ab	ab	ab
11. Synedra ulna	pr	fw	fw	fw	fw	pr		pr	pr	pr	fw	fw	sc		pr	pr	pr	pr		pr	pr	pr	pr	fw	fw	fw	fw
12. Tabellaria fenestrata	ab	ab	ab	ab	ab	ab	ab	ab	ab	c	c	c	c		sc	pr	pr	pr						pr	pr		
13. Tabellaria flocculosa	fw	fw	fw	sc	sc	pr	pr	pr																			
CHLOROPHYCEÆ.																											
1. Arthrodesmus																							pr			pr	
2. Botryococcus	pr	pr	pr	pr	pr	pr	pr	pr	pr	pr	pr	pr	pr		pr				pr	pr	pr	pr					
3. Cerasterias	pr									pr																	
4. Cladophora																							pr	pr			
5 Closterium																											
6. Cœlastrum	pr	fw				pr	pr	pr	pr	pr	pr	pr	pr		pr	pr	fw	sc	sc	fw	fw	fw	sc	pr	pr	pr	

	May 1.	May 8.	May 15.	May 22.	May 29.	June 5.	June 12.	June 19.	June 26.	July 3.	July 10.	July 17.	July 24.	July 31.	August 7.	August 14.	August 21.	August 28.	September 4.	September 11.	September 18.	September 25.	October 2.	October 9.	October 16.	October 23.	October 30.
7. Cosmarium	pr	pr	pr	sc	sc	pr	pr	pr															pr				
8. Dictyosphærium			pr	pr	pr	fw	sc	sc	sc	sc	fw	fw	fw		sc	sc	pr	pr			pr	fw	fw	sc	sc		
9. Dimorphococcus						pr											pr										
10. Eudorina			pr	pr	pr	pr	fw						pr		pr		pr	pr		pr	pr	pr	fw	fw	pr		
11. Glœocystis					pr	pr	fw						pr				pr	pr	pr	pr	pr						
12. Micrasterias																							pr	pr	pr		
13. Nephrocytium	pr	pr	pr		pr	pr	pr	pr	pr				pr					pr									
14. Pandorina						pr	pr		pr	fw	fw	fw	sc		pr	fw	fw	sc			pr	pr				pr	
15. Pediastrum boryanum	sc	sc	sc		pr	pr	pr	pr	pr	pr		pr	pr		pr	pr					pr	pr		pr			
16. " duplex					pr	fw	fw	pr	pr	pr							pr							pr			
17. Pleurotæniopsis																											
18. Protococcus			pr	pr	pr	pr		pr	pr						pr									pr	pr		
19. Raphidium polymorphum var. aciculare	pr					pr																					
20. Raphidium polymorphum var. falcatum	fw	pr	pr					sc	sc	sc	pr	sc					pr	pr						pr			
21. Raphidium polymorphum var. sigmoidea																											
22. Scenedesmus bijugatus						pr													pr				pr				
23. " quadricauda	sc	pr	pr	pr		pr	pr	sc	sc	pr	pr	sc	fw		sc	pr		pr	pr		pr	pr			sc	sc	pr
24. " obliquus																											
25. Spirogyra						pr										pr											
26. Staurastrum crenulatum																											
27. " minneapoliense																											
28. " paradoxum		pr			pr														pr	pr	pr			pr	pr		
29. " sebaldi																				pr							
30. Stigeoclonium					pr																						
31. Tetraspora																		pr		pr	pr						
32. Volvox globata																											
PERIDINEÆ.																											
1. Peridinium	c	sc	fw	fw	fw	fw	pr	pr	pr		pr	sc	fw		fw	fw	c	c	ab	sc	sc	pr		pr			
2. Ceratium tripos	pr	pr	pr	pr	pr	pr	pr		pr				pr		fw	fw	sc	sc	sc	sc	pr	pr	pr		pr		



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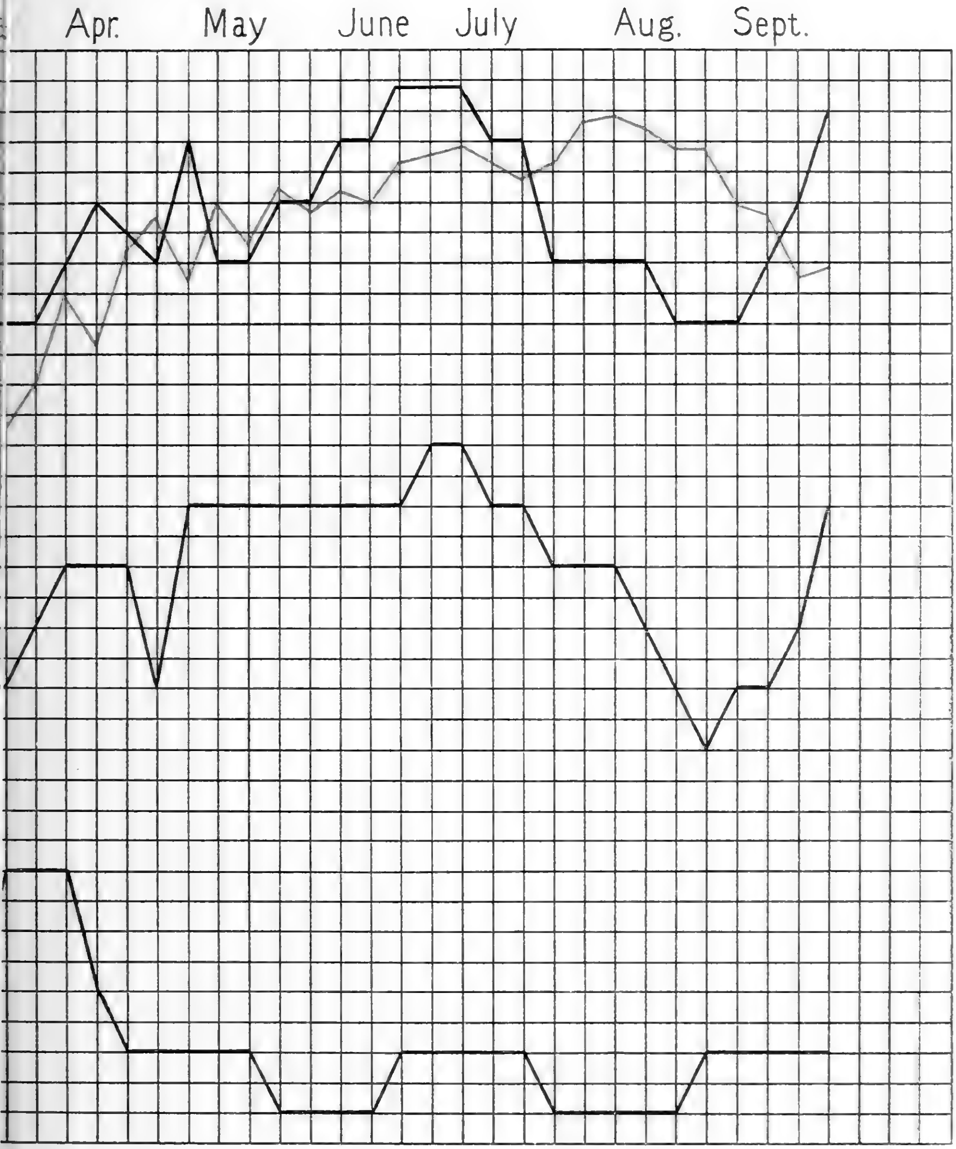

XL III.

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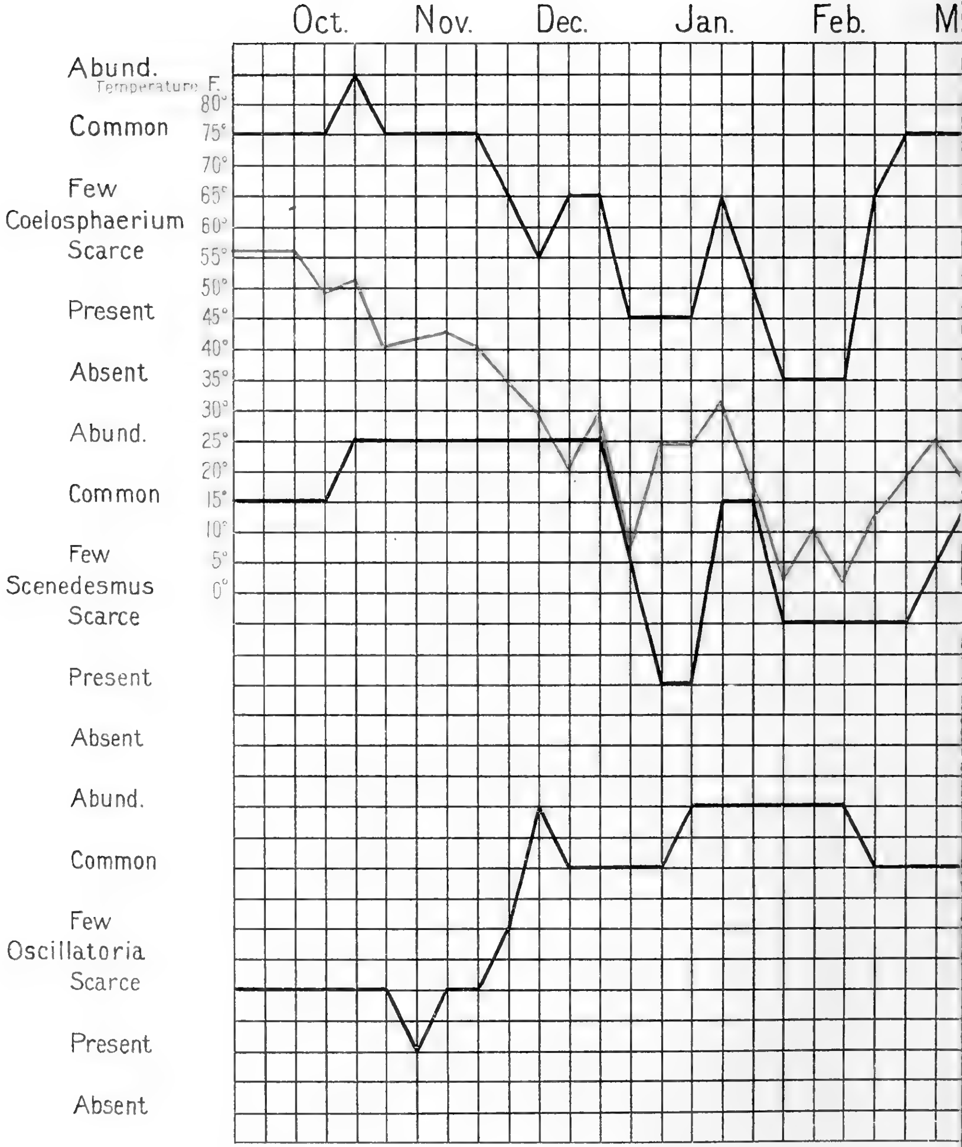

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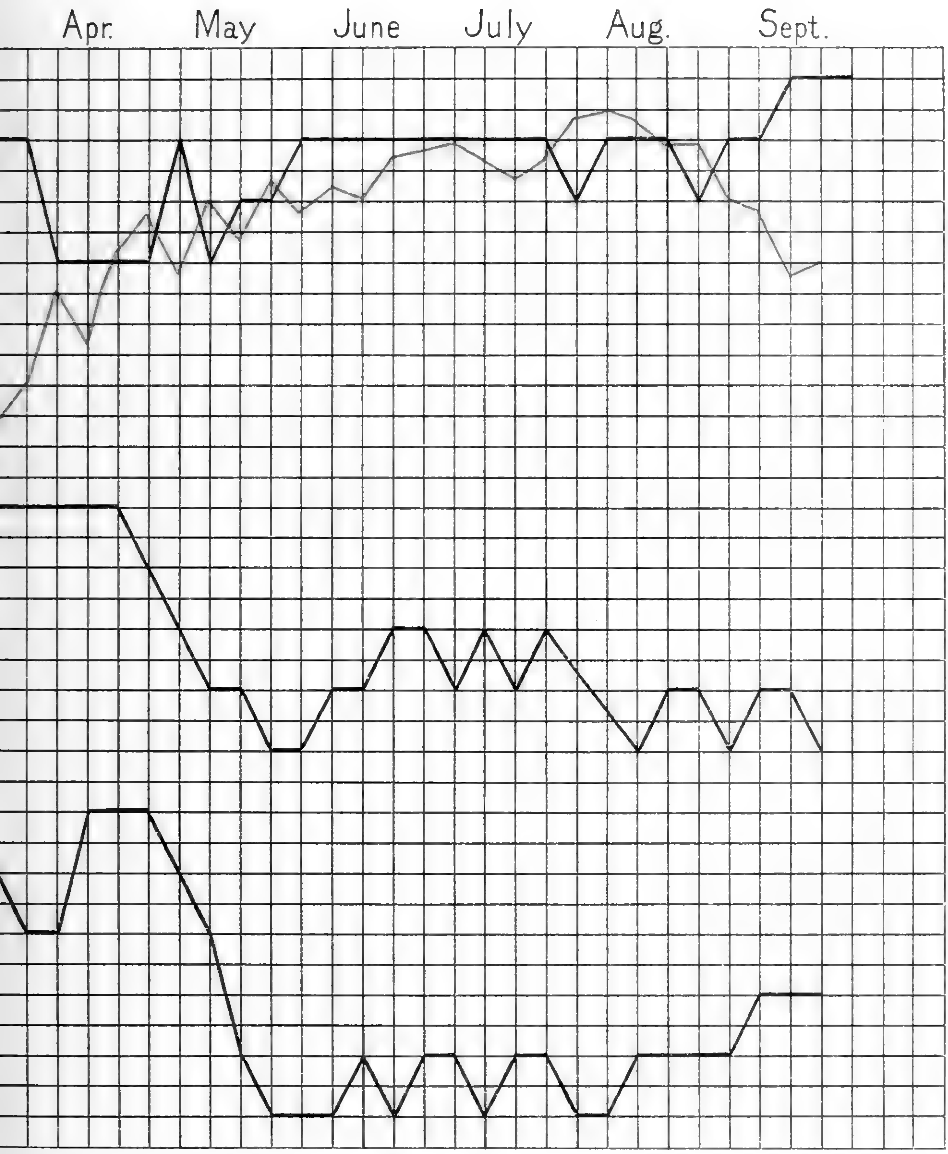

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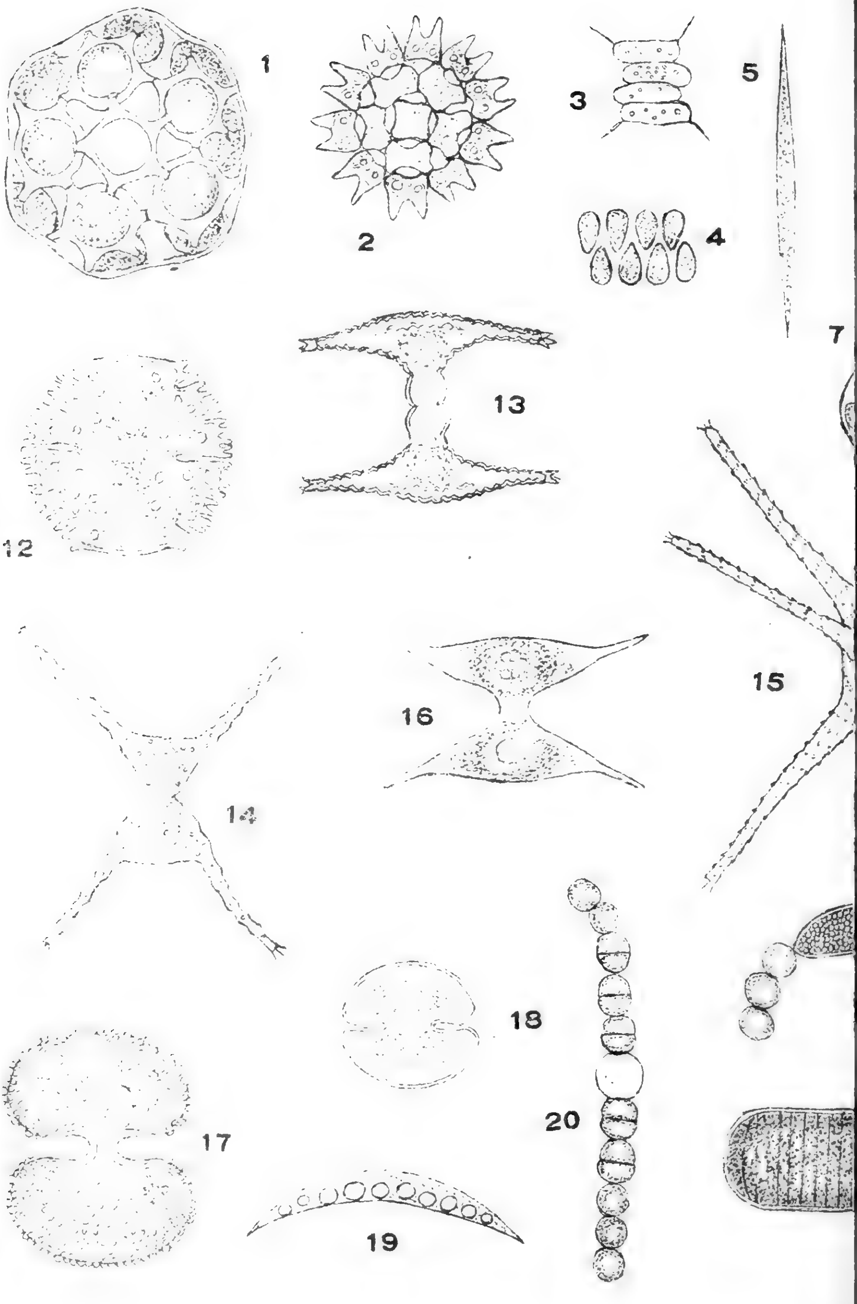

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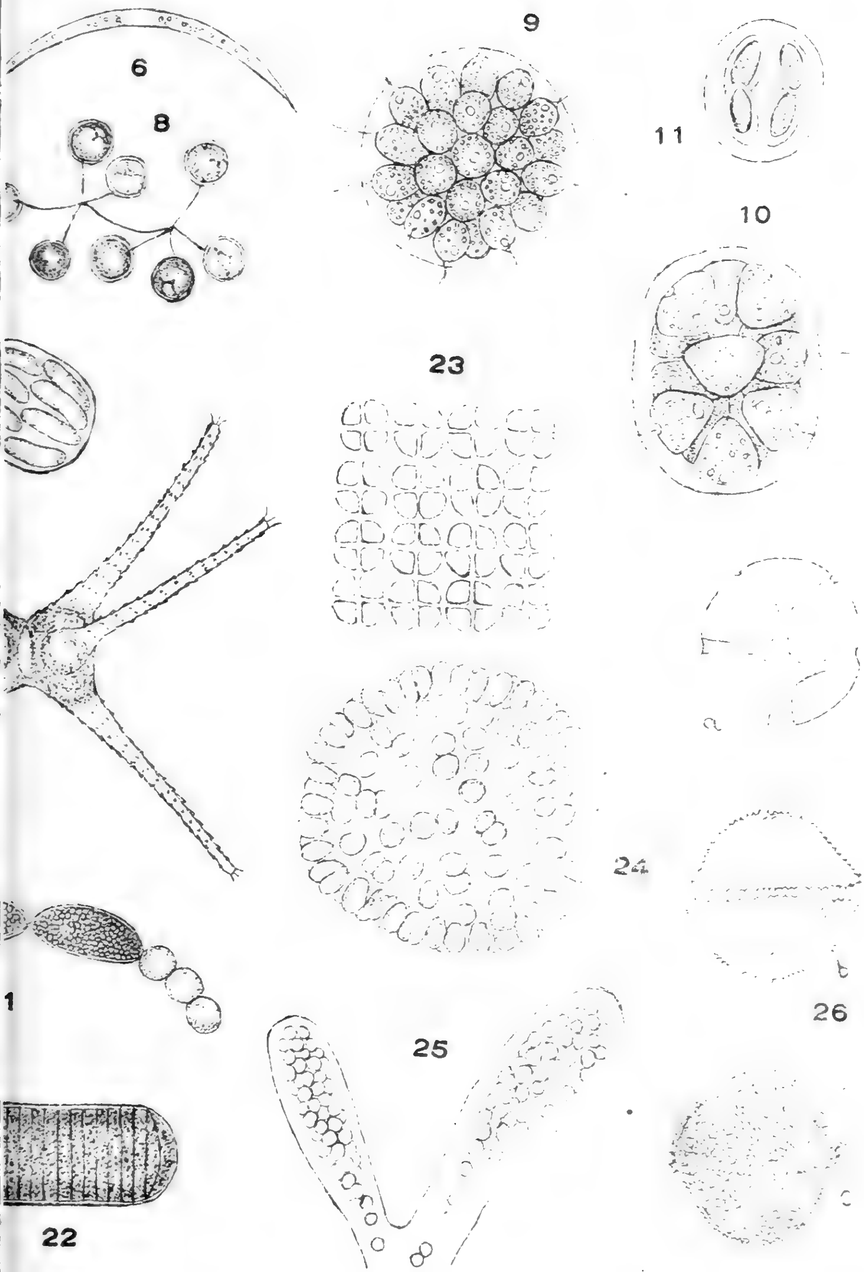

XLV.

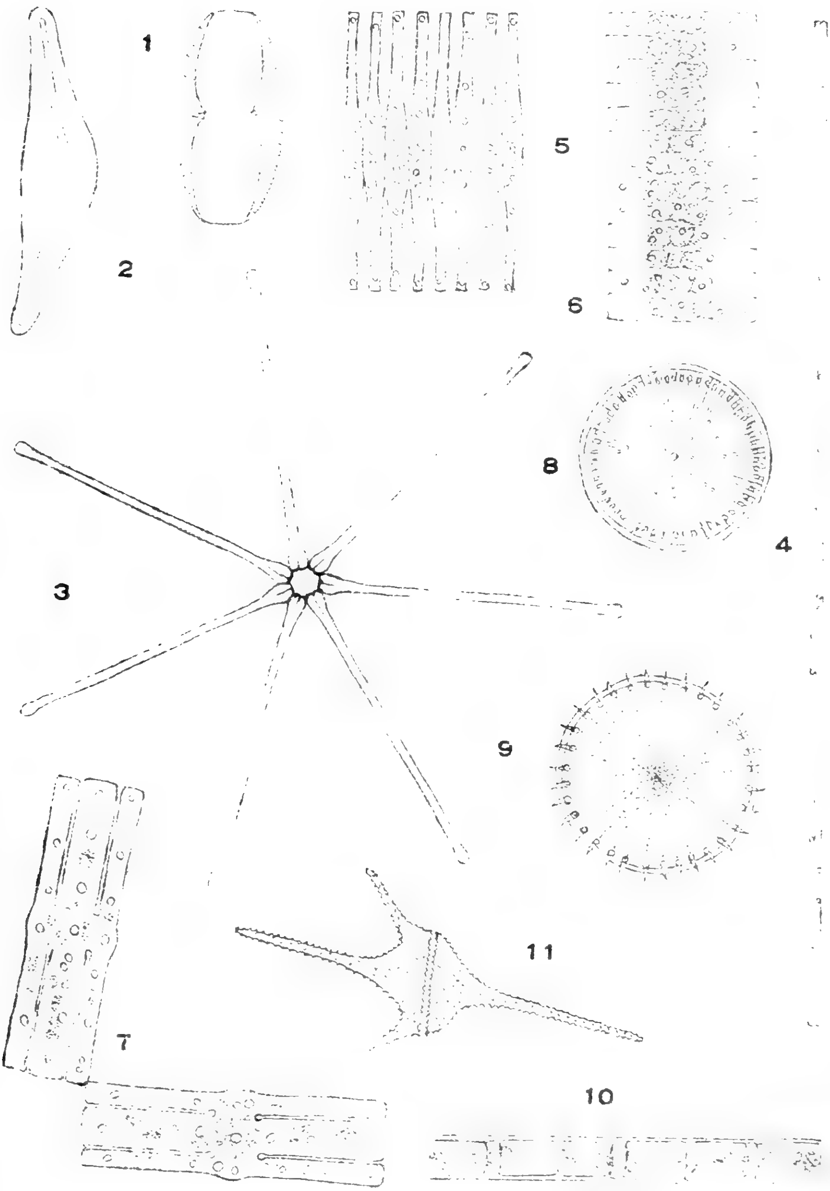

PLATE XLVI

THE HELIOTYPE PRINTING CO., BOSTON.

XXXV. NOTES ON SOME PLANTS OF ISLE ROYALE.

W. A. Wheeler.

During August, 1900, I spent about two weeks at Tobin Harbor on the eastern end of Isle Royale, Mich. At this time I made a collection of plants numbering about 150 species, of which the following seem to be worthy of note.

Botrychium lunaria (L.) Sw. Schrad. Journ. Bot. **2**: 110. 1800.
Rare in moist woods and thickets.

Botrychium virginianum (L.) Sw. Schrad. Journ. Bot. **2**: 111. 1800.
Prothallia and young sporophytes were collected in a thicket near the shore of the lake on Aug. 30. Previous collections of the prothallia of this species have been made only by Professor Douglas H. Campbell at Grosse Isle, Michigan, in 1893 and by Professor E. C. Jeffrey at Little Metis, Quebec, Canada, in 1895.

Woodsia ilvensis (L.) R. Br. Trans. Linn. Soc. **11**: 173. 1812.
Very common on exposed rocks along the lake shore.

Dryopteris fragrans (L.) Schott, Gen. Fil. 1834.
Common on exposed rocks with *Woodsia ilvensis*.

Cryptogramme acrostichoides R. Br. App. Franklin's Journ. 767. 1823.
Infrequent on rocks. This is probably one of the rarest ferns of the Great Lake region.

Lycopodium selago L. Sp. Pl. 1102. 1753.
Frequent on rocks near the shore.

Selaginella selaginoides (L.) Link, Fil. Hort. Berol. 158. 1841.
Frequent on moist, shaded rocks near the water's edge on the shore of the harbor.

Calamagrostis langsdorfii (LINK.) TRIN. Unifl. 225. 1824.

Previously collected from Isle Royale in 1865 by T. C. Porter. This may be the collection reported in Beal & Wheeler's Flora of Michigan as *C. lapponica* Trin.

Carex abacta BAILEY, Bull. Torr. Club, **20**: 427. 1893.

Carex limosa L. Sp. Pl. 977. 1753.

Juncus articulatus L. Sp. Pl. 327. 1753.

Sagina nodosa (L.) FENZL, Verbr. Alsin. 18. 1833.

Infrequent on moist rocks.

Sisymbrium humile MEYER, in Ledeb. Fl. Alt. **3**: 137. 1831.

Rare on rocks.

Echinopanax horridum (SMITH) DEC. & PLANCH. Rev. Hortic. 105. 1854.

The occurrence of this plant in a locality so far removed from what had been considered its native home is certainly remarkable. No collections of it have been reported farther east than the Rocky Mountains of Montana and British Columbia. On Isle Royale it occurs on the rocky cliffs at two places near Tobin's Harbor, *i. e.*, Passage Island and Black's Point and has the appearance of being indigenous.

Gentiana rubricaulis SCHWEIN, in Keating's Narr. Long's Exp. **2**: 384. 1824.

Frequent in moist open places and on protected rocks.

Castilleja acuminata (PURSH) SPRENG. Syst. **2**: 775. 1825.

Euphrasia americana WETTST. Mon. Euph. 127. 1896.

Aster lindleyanus T. & G. Fl. N. A. **2**: 122. 1841.

Erigeron acris droebachianus (O. F. MUELLER) BLYTT. Norg. Fl. **1**: 562. 1861.

Senecio discoideus (HOOK.) BRITTON, in Britton & Brown, Ill. Fl. **3**: 479. 1898.

XXXVI. REVEGETATION OF TRESTLE ISLAND.

D. Lange.

The piece of land I have named Trestle island lies in the southwest part of Lake Phalen, near St. Paul, Minnesota. The island consists of an East and a West section separated from each other by a twenty-five foot embankment of the St. Paul & Duluth Railroad.

The Season of 1898.

Up to the spring of 1898, the road maintained a trestle over the shallow southeast bay of Lake Phalen in place of the present embankment. When the trestle was filled in between April 10, and June 1, 1898, the gradually increasing weight of the dumped material caused the soft lake bottom marl which, according to the statement of the road's engineer, is from 6 to 35 feet thick, to slip out laterally; and with many folds, wrinkles and fissures it rose from a few inches to ten feet above low water level of the lake. Although the engineer in charge tried to prevent the slipping of the marl by means of pontoons, the movement did not cease until about 2500 square yards of lake bottom had risen and become dry land. Of this land about 1500 square yards rose east of the track out of 6 inches to 3 feet of water, and will be called the East section in this paper, the other 1000 square yards rose West of the track out of 3 to 5 feet of water and will be referred to as the West section. Both sections have been under the writer's observation from April 1898, to October 15, 1900, and it is intended to show in this paper the most marked changes in the vegetation of Trestle island.

Early in June, 1898, both sections presented a curious system of curved ridges and crevices running generally parallel to one another and looking like miniature mountain ridges, valleys, and gaping faults; and even small lakes with snails and other aquatic creatures were to be seen. Many of the crevices were over two feet deep and while the opposite walls approached each other below, the gap at the surface was in many cases eight inches wide. The West section was an expanse of mud ridges entirely bare of vegetation, and was at first too soft to admit of a man passing over it; the East section, however, having risen out of shallower water and partly out of a marsh, exhibited specimens of yellow pond lilies (*Nymphea advena*), cattails, water plantain, and common rush lifted out of the water and struggling under adverse conditions.

In the early part of July, 1898, the East section looked already green from the distance. The aquatic plants just mentioned still lived, but showed the effects of changed conditions. The leaves of *Nymphea advena*, for instance, were all very short-petioled, and were below normal size, appeared more or less brownish and the younger ones were rolled from both margins inward and upward. On the other hand, the number of true land plants growing vigorously was already bewildering and although most of them were still too young for a reliable indentification, the following were found in bloom about July 5, 1898;*

1. White clover (*Trifolium repens*).
2. Red clover (*Trifolium pratense*).
3. Wild mustard (*Brassica nigra*).
4. Peppergrass sp.
5. Mayweed (*Anthemis cotula*).
6. Crucifer sp.
7. Black nightshade (*Solanum nigrum*).
8. Mustard sp.
9. *Polygonum* sp.
10. Timothy grass (*Phleum pratense*).
11. Grass sp.
12. Kentucky bluegrass (*Poa pratensis*), out of bloom.

The southern part of this section was covered with a compact layer of fine silt from the railroad embankment and on this firm soil little else but young mosses were growing. Scattered over the higher part of the whole section were young cottonwoods and willows.

The most interesting plants found, however, were the prothallia of horsetails, probably of *Equisetum arvense*, as that

* The botanical nomenclature of this paper follows the "Illustrated Flora" of Britton and Brown.

species is very common along the railroad track south of the island. These prothallia were little green clumps from 1/8 to 1/4 of an inch in diameter and grew mostly on the walls of the shaded mud cracks. From many of them one or more thin young horsetails were protruding. Although I carefully searched the cracks for these prothallia in the springs of 1899 and 1900, I did not again find a single specimen. In 1898 they were abundant on both sections of the island, but they did not grow on the marl, but only on silt and in silt cracks. This silt consisted of a brownish clay and of very fine quartz sand, making a compact damp soil.

The West section was still quite bare early in July, 1898. The creviced marl ridges had dried in the sun and exhibited white streaks like limestone. These little crags and points were bare, but in shaded and sheltered depressions mosses covered much of the damp marl; and small cottonwoods, aspens and willows were scattered over the whole West section.

About September 10th the aspect of both sections had changed, but most markedly that of the East section, which was a veritable wilderness of weeds. Its lower portion was covered with wild rice, over six feet high. Under the rice and also on the higher ground water hoarhound (*Lycopus americanus*), skullcap (*Scutellaria laterifolia*) and American wild mint (*Mentha canadensis*) formed dense tangles and grew with a luxuriance I had never seen before. There were present in great confusion nearly all the plants mentioned in the count of August 16, 1899, and a few not found at that day. In this weeds' paradise the young willows could be seen, but they were not at all conspicuous. No bare ground was now visible on this section, but in walking through the weeds, one could not avoid frequent stumbling into the cracks. The West section at this time presented the appearance of a loose growth of young cottonwoods, aspens and willows, with the cottonwoods most and the willows least conspicuous, but much bare soil could still be seen even from a distance.

On both sections all the young trees remained green and continued to grow until late in the fall. On October 22d they were still green but had evidently ceased growing on account of the cool weather that had prevailed since the third of the month. Of the East section my notes for October 22d say: "A great wilderness of dead weeds."

The Season of 1899.

Although Trestle island was visited during the winter of 1898–99 and was also observed during the spring and early summer of 1899, I shall at once proceed to a midsummer sketch of it, as it appeared from August 14 to 16, 1899.

Compared with the preceding season, the West section had this time changed most rapidly and radically. The mud flat of fourteen months ago was now a thicket of young peach-leaved willows (*Salix amygdaloides*). The cottonwoods (*Populus deltoides*) and the aspens (*Populus tremuloides*) so conspicuous last year were now hidden by the willows, which had grown so large that a herd of cattle or horses would have been completely concealed. Although the high railroad embankment was not more than forty feet from the spot where I wrote up my notes, I could only get glimpses of it along the sky line. Within fourteen months there had grown from the tiny, wind-carried willow seeds a thicket of trees that were large enough to completely shade my paper and exclude the southwest breeze, while two of the young trees were stout enough to afford me a secure and comfortable back rest. One of them, by actual measurement, was 11 feet 3 inches high and had a diameter of 1¼ inches at a distance of four inches above the ground. All the larger trees of this species were approximately of that size and showed a growth of about five feet for the season. A few of the cottonwoods not standing very close to any *Salix amygdaloides* were about as tall, but not as thick as the *Salix*, while the aspens and three or four other species of willow were much smaller and showed only a growth of about three feet for the season. It was clear that the peach-leaved willow would be the dominant plant on this section. It has clearly won the battle against the cottonwoods; and other trees and herbs will occupy a subordinate position. The West section is a willow island.

Lack of space forbids to enlarge upon the herbs and grasses on this section, but it should be mentioned that a fringe of cat-tails (*Typha latifolia*) and arrowheads (*Sagittaria latifolia*) is forming on the lake side of the West section. These plants grow there in 6 to 12 inches of water, where the whitish marl was not raised above low water level although it was elevated considerably.

The East Section from August 14 to 16, 1899.—The great diversity of plant life on this section already referred to continued for this season. In this diversity and in the comparative paucity of trees it presented a striking contrast to the West section, where all true land herbs struggled under the over-shadowing trees.

On the East section, peach-leaved willows dominated the south corner. A crescent, which under the effect of higher water, formed last year a dense rice marsh, with a thick tangled undergrowth of water hoarhound and mad-dog skullcap is now a meadow of tangled rice cut-grass (*Homolocenchrus oryzoides*). The remainder of the section is covered by a very much mixed vegetation, amongst which peach-leaved willows, slender pink persicaria, giant sunflower, a few specimens of wild rice, and cattail are most conspicuous although not most numerous.

The most notable changes, besides the one of the rice marsh to a cut-grass meadow, are the complete disappearance of water-lilies, wild rice, and common rush from the higher ground, the appearance of slender pink persicaria on well-marked areas, and the establishment of willow domination in the south corner.

Not a hand's breadth of bare soil is any longer visible on either section, except in deep crevices. To show clearly the distribution of plant life on this section in midsummer of 1899, I give here the result of a count made on August 16, 1899.

I. Plants established in large numbers and forming the bulk of the vegetation.

1. Peach-leaved willow (*Salix amygdaloides*). In the south corner.

2. Rice cut-grass (*Homolocenchrus oryzoides*). On an east crescent.

3. Slender pink persicaria (*Polygonum incarnatum*). In well-defined patches.

4. Mad-dog skullcap (*Scutellaria laterifolia*). General under the taller plants.

5. Cut-leaved water hoarhound (*Lycopus americanus*). General under taller plants.

6. American wild mint (*Mentha canadensis*). General under taller plants.

7. Common ragweed (*Ambrosia artemisiæfolia*). On highest ridges, where common rush grew in '98.

8. Horseweed (*Leptilon canadense*). On the higher ridges, where common rush grew in '98.

II. Aquatics, marsh plants and cryptogams which were still struggling along in a few spots. July of this year, the most important month of growth for annual and perennial herbs in this region was unusually dry, showing a monthly deficiency in precipitation of 1.75 inches.* This condition was unfavorable for aquatics and marsh plants, but favorable for such plants as horseweeds and common ragweeds.

1. Wild rice (*Zizania aquatica*).
2. Water plantain (*Alisma plantago-aquatica*).
3. Common rush (*Juncus effusus*).
4. Broad-leaved cattail (*Typha latifolia*).
5. Tuberous white water lily (*Castalia tuberosa*). Identified from leaves only.
6. Large yellow pondlily (*Nymphea advena*). Leaves only, a flower bud found an inch deep in wet soil.
7. Horsetails; mosses, amongst them *Funaria hygrometrica;* liverworts, with *Marchantia polymorpha* fairly common.

III. Plants of which only a few scattered specimens were found.

1. Slender nettle (*Urtica gracilis*).
2. Swamp milkweed (*Asclepias incarnata*).
3. Smooth bur-marigold (*Bidens lævis*).
4. Marsh skullcap (*Scutellaria galericulata*).
5. Blue vervain (*Verbena hastata*).
6. White vervain (*Verbena urticifolia*).
7. Beggarticks (*Bidens frondosa*).
8. Aster-like boltonia (*Boltonia asteroides*).
9. Rough cinquefoil (*Potentilla monspeliensis*).
10. Great ragweed (*Ambrosia trifida*).
11. American cocklebur (*Xanthium canadense*).
12. Prickly lettuce (*Lactuca scariola*).
13. *Lactuca* sp.
14. Heart-leaved willow (*Salix cordata*).
15. *Salix* sp.
16. Cottonwood (*Populus deltoides*).
17. American aspen (*Populus tremuloides*).
18. Sullivant's milkweed (*Asclepias sullivantii*). Identified from leaves only.

* The rainfall data of this paper are taken from the Monthly Meteorological Summary of the United States Weather Bureau for St. Paul, Minn.

19. Water pepper (*Polygonum hydropiper*).
20. Climbing false buckwheat (*Polygonum scandens*).
21. Lamb's quarter (*Chenopodium* sp.).
22. Dock (*Rumex* sp.).
23. Giant sunflower (*Helianthus giganteus*).
24. Black-eyed Susan (*Rudbeckia hirta*).
25. Common thoroughwort (*Eupatorium perfoliatum*).
26. Late goldenrod (*Solidago serotina*).
27. Canada goldenrod (*Solidago canadensis*).
28. Prairie mugwort (*Artemisia gnaphaloides*).
29. Bushy aster (*Aster dumosus*). Identified from leaves only.
30. Red clover (*Trifolium pratense*).
31. Peppergrass (*Lepidium* sp.).
32. Tall sisymbrium (*Sisymbrium altissimum*).
33. Black mustard (*Brassica nigra*).
34. Black nightshade (*Solanum nigrum*).
35. Bristly buttercup (*Ranunculus pennsylvanicus*).
36. Swamp willow-herb (*Epilobium palustre*).
37. Common evening primrose (*Onagra biennis*).
38. Canada thistle (*Carduus arvensis*).
39. Common thistle (*Carduus lanceolatus*).
40. Water hemlock (*Cicuta maculata*).
41. Nodding wild rye (*Elymus canadensis*).
42. Squirrel-tail grass (*Hordeum jubatum*).
43. Grass sp.
44. Grass sp.
45. Grass sp.
46. Grass sp.
47. Sedge (*Cyperus* sp.).

The Season of 1900.

The last half of October, 1899, was quite dry and at the end of the month the United States Weather Bureau reported an accumulated deficiency in precipitation since January first of .73 inch. On some day between October 29 and November 4, 1899, a prominent factor in plant distribution appeared on the East section of Trestle island. Fire changed the wilderness of dead, dry weeds into a black, ashy waste.

On May 6, 1900, the East section looked, on the whole, still barren and black. All the over-ground parts of the young trees that had grown scattered amongst the weeds were found to have been fire-killed, but about one-half of their number had grown out again near the ground. The larger ones in the south corner had not been killed, because there the weeds had not grown as thick.

Patches of the perennials, *Elymus canadensis* and a few other grasses, as well as goldenrods, sunflowers and nettle were coming out vigorously. The rice cut-grass, however, although it seems to be perennial, had a very poor start. On close examination numerous seedlings of annuals were found, but all looked brownish and sickly on account of the dry weather and the glaring sunlight. Although most of them were not readily identified, I recognized the following without difficulty:

1. *Polygonum* sp.
2. *Mentha* sp.
3. *Carduus lanceolatus*, the seedlings of which looked quite green and vigorous.
4. *Lactuca* sp.
5. *Brassica nigra*.
6. *Chenopodium* sp.

The spring and summer of 1899 were excessively dry in this region so that, since January 1st a continued accumulated deficiency of rain of over 4 inches was reported from May 31st to August 31st. About June 10th another new factor, one that is able to destroy all plant life not perennial or not armed in some way, appeared on the scene—*cattle*, a large herd of hungry dairy cows. In their search for green grass they had passed over the dried-up marsh and along at the foot of the embankment and had discovered the East section of Trestle island.

In the end, however, bovine instinct for plant selection proved of some interest, for, when after an absence of over two months, I visited the place again about Sept. 10th, there was a closely cropped, rough, much trampled piece of pasture. Where a year ago about 60 different plants had grown in wild exuberance, only about 40 cropped and crippled trampled species were to be found* and only a single one of these bloomed and flourished in large numbers, the formidable armed thistle, *Carduus*

* About 30 species of the list of August 16, 1899, had survived fire and cattle and about 10 species were found that do not appear on the list of August 16, 1899.

lanceolata. It has occupied nearly one third of the section and next summer, I think, the thistle will keep the cows off the grass, and as the West section is a willow island, the East section will be a thistle island.

During September, 1900, there was over 5 inches of rain and now water once more surrounds the East section and the cows have not been there since about October 1st.

The West Section in the Season of 1900.—The lake has risen about two feet since September 15th this year and the south half of the section is under water. Fire and cattle have thus far never invaded this section. The willows are thriving. There are probably five species of them, but *Salix amygdaloides* forms the thicket. There are a few thrifty cottonwoods, and aspens, one balsam poplar, and one slippery elm, *Ulmus fulva*. Although sumac, hazel, box-elder, silver maple, wild haw, flowering dogwood and three species of oak grow within half a mile and most of them within a stone's throw of the island, not one individual of all these has been found on either section of Trestle island.

Last spring several of the willow species, when they were only about 24 months old, bloomed for the first time and produced fruit. A count on May 11th revealed 38 staminate individuals and 27 pistillate individuals of *Salix amygdaloides* in flower. The count was then made to include older trees of the same species along the cycle path near the island and of a total of 135 trees counted 74 bore male and 61 bore female flowers. Although a number of the trees were measured last year, only a few recent measurements of October 12, 1900, can be given here.

Number.	Diameter at 4 inches above the ground.	Height measured along the stem.	Growth of this season.
1. *Salix amgydaloides.*	3 inches	15 ft. 2 in.	7 ft. 2 in.
2. *Salix amygdaloides.*	3 "	16 ft. 10 in.	Uncertain.
3. *Salix amygdaloides,*	2½ "	18 ft.	7 ft. 3½ in.
4. *Populus deltoides.*	1½ "	14 ft. 3½ in.	6 ft. 9½ in.
5. *Populus deltoides.*	1¼ "	15 ft. 9 in.	6 ft. 6 in.
6. *Populus tremuloides.*	1 "	10 ft. 7 in.	4 ft. 2 in.
7. *Ulmus fulva.*	½ "	4 ft. 8 in.	2 ft. 9 in.

There are many willows on this section of the size of those measured, while the two cottonwoods and the aspen measured are the largest that could be found and the elm is the only individual present. The average size of the large vigorous *Salix* *amygdaloides* individuals is about 2½–3 inches in diameter at four inches from the ground, and 16 feet in height. The largest cottonwood, No. 5, shows a horizontal spread of its top of 2½ feet, while a willow (*S. amygdaloides*) near it spreads its branches 8 feet in a horizontal diameter. A number of trees have been marked and their study as well as that of the whole island is being continued. The willows are now so large that for some time a flock of English sparrows regularly roost in them and they seem to prefer the part of the section that is flooded.

Animal Life of the Island.

Did the limits of this paper permit, an interesting chapter might be added under this heading. Crayfish, voles, mice, and muskrats burrow under and in the island, since the summer of 1898, the cottontails resort to it, and in August of 1899 some minks had made their home under the old ties, which once formed the engineer's pontoon. Near the mink's home a song-sparrow had hatched its young on a thistle bush. Some of the young trees on the West section have been infested with the spotted willow aphid, *Melanoxanthus saliciis*,* since the summer of 1899 and their secretions attract swarms of flies and wasps. That the frogs are there is self-evident, but I also captured a fine green tree-frog, and a bunch of prickly caterpillars of the morning-cloak butterfly, *Euvanessa antiopa*, found their table spread on the willows.

* Identified by Dr. Otto Lugger.

XXXVII. VIOLET RUSTS OF NORTH AMERICA.

J. C. ARTHUR AND E. W. D. HOLWAY.

A rust of violets, in its three forms of æcidium, uredo and teleutospore, is common throughout North America upon nearly all indigenous species of the genus *Viola*. For the most part it belongs to a single species, *Puccinia Violæ* (SCHUM.) DC., which is also the common violet rust of Europe and of some other regions. This, at least, is the conclusion to which we have arrived after a rather extended study of considerable material. Beside the one common rust there is a peculiar *Æcidium* throughout the eastern part of North America, and one species of *Puccinia* in the western part, both distinctly American.

In this connection we desire to acknowledge the kindness of the New York Botanical Garden, the Botanical Department of the University of Illinois, and of the Iowa State College, in loaning material from their herbaria, and to extend our thanks to their representatives. We wish also to thank Dr. J. J. Davis, of Racine, Wis., and Mr. E. Bartholomew, of Rockport, Kans., for aiding us with specimens and information. We are furthermore grateful to Mr. Stewardson Brown, curator of the herbarium of the Philadelphia Academy of Sciences, for the privilege of examining material in the Schweinitz collection, and to the custodians of the Gray Herbarium of Harvard University and of the New England Botanical Club, from the examination of whose phanerogamic collections of *Viola*, five specimens of rust were obtained in the former instance and three in the latter.

In this article for conciseness we have used in addition to the usual I, II and III for designating the æcidium, uredo and teleutospore stages, the sign O for the spermogonial stage. In citing specimens these signs are put into large type when the stage is present in abundance, and into small type when subordinate and in small amount.

Æcidium pedatatum (SCHW.) nom. nov.

SYN.:

1834. *Cæoma* (*Æcidium*) *pedatat*[illegible] Tra[illegible] Amer. Phil. Soc. 4: 293, no. 2[illegible]

1834. *Cæoma* (*Æcidium*) *s*[illegible] Trans. Amer. Phil. Soc. 4: 293 [illegible]

1672. *Æcidium Mariæ-*[illegible] Rep. N. Y. Mus. for 1870: 92.

1874. *Æcidium Petersii* [illegible] 61.

EXSICC.:

Carleton, Ured. Amer. [illegible]

Heterœcious, inhabiting species [illegible]*a*, and also of some other genus of plants not yet determin[illegible].

O. Spermogonia preceding the æcidia.

I. Æcidia hypophyllous, seated on small, pale, circumscribed, unthickened spots; cups usually sub-circinating, small, shallow or short cylindrical, white, border narrow, often much split and somewhat recurved; spores subglobose, in part angular from compression, epispore thin, minutely verrucose, 11 to 18 μ, averaging 14 μ.

Throughout the United States east of the Rocky mountains, from March to June on the blades of various species of violets, and less often on the petioles, pedicels and calyx. Specimens have been examined as follows:

On *Viola obliqua* HILL. Pennsylvania (*Schweinitz*), Maine (*Blake*), Indiana (*Arthur*), Illinois (*Seymour*, *Arthur*), Iowa (*Holway*), Kansas (*Bartholomew*, *Carleton*).

On *Viola ovata* NUTT. New Jersey (*Ellis*).

On *Viola sagittata* L. Pennsylvania (*Schweinitz*), Massachusetts (*Asa Gray*).

On *Viola pedata* L. Pennsylvania (*Schweinitz*), Alabama (*Baker*), Iowa (*Holway*).

On *Viola pedatifida* DON. Kansas (*Kellerman*), Iowa *Holway*).

On *Viola primulæfolia* L. District of Columbia (*Greene*), Mississippi (*Tracy*).

On *Viola Nuttallii* PURSH. Kansas (*Bartholomew*).

On *Viola striata* AIT. North Carolina (*Biltmore Herbarium*).

On *Viola tricolor* L. Kansas (*Popenoe*).

The form here described is undoubtedly part of an heterœcious species, having the alternate forms possibly upon carices. It occurs in open woodlands from the last of March to the beginning of June, but is rather infrequent and local. It is distingished from the æcidium of *Puccinia Violæ* by the markedly smaller cups and spores, and by a greater tendency to form small, round groups seated on the mesophyll of the blade, rather than on the midrib or veins. The peridium is usually conspicuously white; the cylindrical elongation noted in the description by Berkeley and Curtis is occasionally to be seen, but must be considered as accidental, depending upon conditions of growth. The same kind of development is met with in other forms of æcidia (see notes on *Æcidium pulcherrimum* Rav. in Bull. Lab. Nat. Hist. of Univ. Iowa **4**: 399–400).

Examination of specimens in the Schweinitz collection at the herbarium of the Philadelphia Academy of Sciences shows that both species which he described as new, occurring on *Viola pedata* and *V. sagittata* respectively, belong here. The name coming first on the page is taken as the authentic name of the species. The Schweinitz specimens on both hosts are ample, but neither shows the æcidia in so characteristic a form as does the specimen in the same collection on *Viola obliqua*, which Schweinitz referred to *Æcidium Violarum*. The last has very small, compactly clustered æcidial cups, in small round groups, while both the former have the cups somewhat larger, and sparsely scattered or solitary. The difference in habit is doubtless due to the influence of the host and the atmospheric conditions affecting the development, in part, combined with the accidental distribution of the infection over the leaf surface.

Spermogonia have not been seen by the writers, but Burrill (Par. Fung. Ill., p. 223) states that they precede the æcidia, although he does not describe them.

Puccinia Violæ (SCHUM.) DC. 1815. Flore Francaise **6**: 62.

SYN.:

1803. *Æcidium Violæ* SCHUM. Fl. Sæll. **2**: 224.
1803. *Uredo Violæ* SCHUM. Fl. Sæll. **2**: 233.
1805. *Æcidium Violarum* DC. Fl. Franc. **2**: 240.
1825. *Puccinia Violarum* LINK. Sp. Plant. **2**: 80.
1875. *Puccinia hastatæ* COOKE, Grev. **3**: 179.
1888. *Puccinia Fergussoni hastatæ* DET. Sacc. Syll. Fung. **7**: 682.
1897. *Puccinia densa* D. & H. Hedw. **26**: 298.
1898. *Dicæoma Violæ* KUNTZE, Rev. Gen. Pl. **3**: 471.

Exsicc.:

Jaczewski, Komarov, Tranzschel, Fungi Ross. no. 16^{III}.
Ellis and Everhart, N. Am. Fungi, nos. 254^{III}, 1007^{I}, 2411^{III}.
Seymour and Earle, Econ. Fungi, no. 456^{III}.
Thueman, Myc. Univ., no. 430^{I}.
Linhart, Fungi Hung., no. 33^{I}.
Krieger, Fungi Sax., nos. 110^{I}, 111^{III}, 472^{II}, 561^{I}, 562^{II}, 1006^{I}.
Rabenhorst, Fungi Europ., no. 2194^{I}.
Sydôw, Mycotheca Marchica, no. 468^{III}.
Sydow, Ured. Exsicc., nos. 33^{III}, 82^{I}, 117^{II}, 286^{II}, 335^{I}, 378^{II}, 640^{I}, 935^{I}, 1136^{III}, 1184^{I}, 1229^{I}.
Shear, N. Y. Fungi, no. 321^{III}.
Vize, Fungi Brit., no. 77^{I}, 112^{III}.

Autæcious, inhabiting species of *Viola*.

O. Spermogonia preceding or accompanying the æcidia, amphigenous, punctate, honey yellow; spores elliptical or nearly globose, 3 to 5 μ broad by 4 to 6.5 μ long.

I. Æcidia hypophyllous and also on petioles, pedicels and calyx, substratum moderately thickened, in indefinite and irregular clusters, often covering nearly the whole leaf, especially noticeable on the veins and stalks, crowded; cups broad and low, rather coarsely lacerate and irregularly recurved; spores subglobose, somewhat angular from compression, minutely verrucose, 14 to 18 μ broad by 15 to 22 μ long (European) or 16 to 20 μ broad by 18 to 26 μ long (American); wall thin.

II. Uredo chiefly hypophyllous; sori at first in small groups on discolored spots, later sparsely and indefinitely scattered, soon naked, cinnamon brown, pulverulent; spores subglobose, echinulate, 17 to 28 μ in diameter, brownish yellow; wall varying from thin to thick; pores four, equatorial.

III. Teleutosori hypophyllous, indefinitely scattered, round, small, soon naked, pulverulent, chocolate brown; spores brown, usually broadly elliptical, less often oblong-ovoid or irregular, slightly or not at all constricted at the septum, smooth, or finely tuberculate especially on the upper half, 15 to 23 μ broad by 21 to 30 μ long (European), or 16 to 26 μ broad by 28 to 44 μ long (American); apex obtuse, somewhat thickened, with a pale and broad apicuous, while a similar projection often occurs on one side of the lower cell near the septum; pedicel hyaline, fragile, not as long as the spore, somewhat deciduous.

Throughout North America, occurring upon nearly every indigenous species of *Viola*. Spermogonia and æcidia from April to

June, uredo and teleuto stage from June to November and later along the Gulf region. Specimens of American origin have been examined as follows:

On *Viola obliqua* HILL. 1879? Newton, Mass. III. (*W. G. Farlow*); 1882, Decorah, Iowa III (*E. W. D. Holway*); 1883, Madison, Wis. I (*L. H. Pammel*); 1885, Oregon, Ill. III (*M. B. Waite*); 1885, Decorah, Iowa, ii. III (*E. W. D. Holway*); 1886, Manhattan, Kans. I and ii. III (*W. A. Kellerman*); 1890, Greencastle, Ind. O. I (*J. C. Arthur*); 1893, Terre Haute, Ind. I (*J. C. Arthur*); 1897, Auburn, Ala. I (*Ala. Biol. Surv.*); 1898, Lafayette, Ind. O. I (*J. C. Arthur*).

On *Viola rotundifolia* MICHX. 1890, Bradley, Me. II (*F. L. Harvey*); 1891, Gunflint lake, Minn. i. II. III (*L. S. Cheney*); 1899, St. Louis river, Wis. i. II. iii (*L. S. Cheney*.

On *Viola renifolia* A. GRAY. 1896, Orono, Me. I (*E. D. Merrill*).

On *Viola septentrionalis* GREENE. 1898, Ottawa, Ont. I (*J. M. Macoun*).

On *Viola blanda* WILLD. 1885, Lansing, Mich. ii. III (*J. C. Arthur*); 1886, Vermilion lake, Minn. II. iii (*E. W. D. Holway*); 1892, Oakland Co., Mich. II. iii (*G. H. Hicks*); 1899, Isle au Haut, Me. ii. III (*J. C. Arthur*).

On *Viola primulæfolia* L. 1892, Lake City, Fla. II. iii (*P. H. Rolfs*); 1899, Isle au Haut, Me. ii. III (*J. C. Arthur*).

On *Viola lanceolata* L. 1897, Sault Ste. Marie, Mich. II. (*E. T. Harper*); 1899, Isle au Haut, Me. ii. III (*J. C. Arthur*).

On *Viola cognata* GREENE. 1894, North Yakima, Wash. ii. III (*C. V. Piper*); 1894, Sisson, Calif. ii. III (*W. C. Blasdale*).

On *Viola adunca* SMITH. 1887, Provo, Utah, ii. III (*S. M. Tracy*); 1889, Deer Lodge, Mont. I (*F. D. Kelsey*); 1892, Pullman, Wash. I and ii. III (*W. R. Hull*); 1894, Pullman, Wash. II. iii (*C. V. Piper*); 1894, Pine Creek, Calif. i. II. iii (*F. P. Nutting*); 1894, Sisson, Calif. I (*E. W. D. Holway*); 1894, Sisson, Calif. II. iii (*W. C. Blasdale*); 1899, Gunnison Co., Colo. ii. III (*E. Bartholomew*).

On *Viola glabella* NUTT. 1885, Falcon Valley, Wash. ii. III (*W. N. Suksdorf*); 1895, Skamania Co., Wash. III

(*W. N. Suksdorf*); 1897, Bingen, Wash. I. II. III (*W. N. Suksdorf*).

On *Viola ocellata* TORR. & GR. 1894, Ukiah, Calif. ii. III (*E. W. D. Holway*).

On *Viola Montanensis* RYDB. 1888, Helena, Mont. II. III (*F. D. Kelsey*); 1897, Spanish Basin, Mont. ii. III (*P. A. Rydberg*); 1898, Montesanes, Wash. ii. III (*A. A. Heller*).

On *Viola Canadensis* L. 1889, Bozeman, Mont. O. I (*Mrs. Alderson*).

On *Viola striata* AIT. 1882, Pine Hills, Ill. I. ii. III (*A. B. Seymour*); 1882, Carbondale, Ill. I (*A. B. Seymour*); 1893, Ell River Falls, Ind. ii. III (*L. M. Underwood*).

On *Viola rostrata* PURSH. 1886, Syracuse, N. Y. I (*L. M. Underwood*).

On *Viola Labradorica* SCHRANK. 1883, Granville, Mass. ii. III (*A. B. Seymour*); 1885, Racine, Wis. ii. III (*J. J. Davis*); 1886, Racine, Wis. I (*J. J. Davis*); 1888, Racine, Wis. ii. III (*J. J. Davis*); 1896, St. Remi, Quebec, ii. III (*Wm. Stuart*).

On *Viola arenaria* DC. 1880, Franklin Falls, N. H. II (*Mrs. Harrison*).

On *Viola hastata* L. 1820? Salem, N. C. I (*L. v. Schweinitz*).

On *Viola pubescens* AIT. 1882, Decorah, Iowa, I (*E. W. D. Holway*); 1883, Madison, Wis. ii. III (*L. H. Pammel*); 1883, Devil's Lake, Wis. III (*L. H. Pammel*); 1883, Decorah, Iowa ii. III (*E. W. D. Holway*); 1885, Madison, Wis. ii. III (*A. B. Seymour*); 1885, Racine, Wis. ii. III (*J. J. Davis*); 1886, Racine, Wis. O. I (*J. J. Davis*); 1886, Decorah, Iowa, O. I (*E. W. D. Holway*); 1889, Greensburg, Ind. I (*J. C. Arthur*); 1898, Lafayette, Ind. O. I (*J. C. Arthur*); 1898, Pownal, Vt. O. I (*J. R. Churchill*).

On *Viola scabriuscula* (T. & G.) SCHW. 1898, Franconia, N. H. I (*E. & C. E. Faxon*); 1898, Masardis, Me. I (*M. L. Fernald*).

On *Viola sp.* 1884, Jamestown, N. D. II. III (*A. B. Seymour*); 1893, Three Lakes, Wis. I (*J. J. Davis*); 1895, Mt. Washington, N. H. ii. III (*E. T. Harper*); 1897, Sault Ste. Marie, Mich. I (*E. T. Harper*); 1899, Pachuca, Mexico II. III (*E. W. D. Holway*).

This species shows remarkable variability, especially in size of the spores, and in the thickness and markings of their walls. These differences come out most strikingly when comparing a series of specimens. There is also considerable variability in the form of the spores, as shown in Figs. 5 and 6, both taken from the same specimen, but it is such as one may expect to find in many other species of rusts.

If almost any specimen of violet rust be compared critically with an European specimen, the greater size of the teleutospores in the former is likely to attract attention. This is the basis of the species proposed by Cooke, *Puccinia hastatæ*. A specimen collected by W. C. Blasdale on *Viola cognata* at Sisson, Calif. (Figs. 5 and 6), has been compared with the type material of *P. hastatæ* at the Kew Herbarium, through the kindness of Mr. Massee, and found to agree very closely. The greater size of the teleutospore in the American material generally is noticeable, and this difference extends to the uredo and æcidial stages as well, although not usually so pronounced. In the case of an æcidium on *Viola pubescens*, collected at Decorah, Iowa, in 1882, Farlow has made the comment:—"Spores somewhat larger than in the European specimens; this *may* be the Æcidium of *Puccinia hastatæ* Cke." (on the label in Ellis' N. Amer. Fungi, no. 1007). If size of spores is to be taken as valid basis for separating species, there is no question that the American form shows a strong claim to rank as autonomous. The claim, even on that assumption, is much weakened, however, by the great range between the smallest and largest of the American specimens, indicating a decided capacity for variability rather than a fixed form.

A peculiarity of the American violet rust, that in the case of European specimens we have not seen mentioned and have not observed, is the frequently tuberculate sculpturing of the teleutospores. Burrill (Paras. fungi Ill.: 174) makes this a diagnostic character, but in a wide series of specimens one does not always meet with it. With most observers the spores would generally be rated as smooth like the European form. The true character of surface markings can be best studied by observing the spores without addition of fluids. In this way it is easy to see that the markings are small papillæ, sparingly distributed, and chiefly appearing on the upper half of the spore. A closer study reveals the interesting fact that when no elevations above the general surface of the spore can be detected, there may yet be observed almost the usual appearance when the spore is examined in face view. Instead of papillæ, their places seem to be supplied by translucent dots. Now the most interesting outcome of this study is the observation that the European specimens, while having what are always rated as smooth teleutospores, yet show when looked at dry and in face view, the same appearance of translucent dots and in the same abundance and distribution as do American specimens. The American form, therefore, simply accentuates characters that are primitive in the trans-Atlantic form.

The uredospores also have interesting, but less significant, characters showing variability. As a rule they do not much exceed in size those from European specimens, although the tendency toward largeness is apparent. But in many American specimens the walls are greatly thickened (compare uredospores in Figs. 5 and 7), and give a striking appearance under the microscope. These thick-walled uredospores are sometimes small, and sometimes large. They occur on various species of violets and range from the Atlantic coast to the Pacific. Fine illustrations are found in material on *Viola primulæfolia* collected at Isle au Haut, Me. (Fig. 8), the uredospores being small, and on *Viola glabella* collected at Bingen, Wash. (Fig. 7), the uredospores being large. After all, the form is only occasionally met with. If it is an adaptation to some particular environment, it is difficult to see what that may be. The form on *Viola primulæfolia* from Maine was collected within a few hundred feet of the open ocean among rocks, yet in the same situation and intermixed grew *Viola lanceolata* with rust showing uredospores having almost normally thin walls.

It is possible that these interesting variations belong in some way to obscure species, but our study has shown no morphological boundaries. It is more likely that they indicate races, or possibly so-called biological species. A well-directed series of cultures would undoubtedly yield important results.

A few words regarding the American synonymy may be helpful. Cooke described *Puccinia hastatæ* in the third volume of *Grevillea* from material collected in Maine by E. C. Bolles. The host was *Viola hastata*. The uredo and teleuto stages are described, but the only distinctive characters are the measurements which are given as 20–22 μ for the uredospores, and

20–25 μ by 35–40 μ for the teleutospores. The name has been very little used by American or other botanists. The assignment of the name to a place under the wholly distinct *Puccinia Fergussoni*, as done by De Toni in the seventh volume of Saccardo's *Sylloge fungorum*, was far from being a shrewd guess as to its relationship. It is even more inexplicable how Dietel could have fancied a resemblance to *Puccinia Fergussoni* in the type material of his *Puccinia densa*. His material of the latter species was collected in 1895 by W. N. Suksdorf in the State of Washington. It was on *Viola glabella*, and yielded only teleutospores. The characters which he drew up for the proposed new species agree perfectly with those of large-spored forms of *Puccinia Violæ*. Beside the type collection we have examined material on the same host from other localities in the same State, and secured by the same collector. This ample material includes all three spore stages, and leaves no doubt of the identity of *P. densa* Diet. with *P. Violæ*.

All the hosts of the specimens cited under *Viola Montanensis*, and part of those under *V. adunca*, have been determined or verified by Dr. P. A. Rydberg of the New York Botanical Garden.

An error in the thirteenth volume of Saccardo's *Sylloge fungorum*, page 1313, should be pointed out here. *Puccinia Mariæ-Wilsoni* Clint. is said to occur on *Viola cucullata* Ait. and *V. delphinifolia* Nutt. The error is due to a confusion of names. *Æcidium Mariæ-Wilsoni* Peck is found on these hosts but *Puccinia Mariæ-Wilsoni* Clinton is only found on *Claytonia*, and both species are widely different from *Puccinia Violæ*.

Puccinia effusa D. & H. 1895. Erythea **3**: 81.

I. Æcidia amphigenous, but chiefly hypophyllous, in large indefinite clusters, often covering much of the leaf, noticeably extending along the veins and petioles; substratum somewhat thickened; cups broad and low, border white, irregularly and coarsely lacerate, somewhat recurved; spores subglobose, somewhat angular from compression, minutely verrucose, 20–27 μ in diameter.

III. Teleutosori for the most part arising from the cups of the æcidia, uncovered, elliptical, nearly black; spores dark brown, elliptical or oblong, slightly if at all constricted at the septum, inconspicuously verrucose, 23–31 μ broad by 37–50 μ long; wall moderately thick; apex rounded, usually not thickened; base rounded or occasionally slightly narrowed; pedicel hyaline, deciduous.

The western coast of the United States in spring and early summer. The following specimens have been examined, the first being the type collection:

On *Viola lobata* BENTH. 1894, Dunsmuir, Calif. I. iii (*E. W. D. Holway*).

On *Viola Nuttallii* PURSH. 1897, Falcon Valley, Wash. I. iii (*W. N. Suksdorf*).

The species is very characteristic. It probably possesses spermogonia, but they have not yet been observed; it is, however, without uredo, although erroneously included in the original description of the species. Two specimens are cited (*Erythea* 3: 82) as type material, the first on *Viola lobata*, referred to above, and the second on *Viola ocellata*. The latter specimen has been examined and proves to be *Puccinia Violæ*, and is cited above under that species. The original description of the species is accordingly emended to omit the supposed uredo.

The difference in the shape of the spores, shown in the photographs of spores taken from the two hosts, is doubtless due to some accident of growth, such as more or less compression in the young sorus, and is without diagnostic value. It is of the same nature as the difference shown in two mountings from the same collection of *P. Violæ* on *V. cognata*. The more regular spores are to be accepted in each case as the normal development under favorable conditions.

Four additional species of violet rusts occur in Europe, and it is possible that they may eventually be found in this country. *Uredo alpestris* Schrœt. inhabits *Viola biflora* L., and as this host is a native of the Rocky Mountains, the rust may possibly accompany it. *Puccinia alpina* Fckl. also occurs on *V. biflora* L., and *P. Fergussoni* Berk. & Br. occurs on *V. palustris* L., and *V. mirabilis* L., and *V. epipsila* Led. Both of these species belong to the section of Micropuccinia, and are notably distinct from the other rusts on violets. A specimen of rust collected by Marcus E. Jones at San Diego, Calif., in 1882, was erroneously referred to the latter species, and distributed by him as No. 3040. *Puccinia ægra* Grove is an autœcious species found on the cultivated pansy and its close relatives. It will probably be brought to America after a time through commercial channels, as the rusts of asparagus, chrysanthemum, carnation, hollyhock, and of some other cultivated plants have been. As the hosts of these four species of violet rusts are found in this country, the rusts may not unreasonably be expected also.

EXPLANATION OF PLATE XLVII.

All figures photographed and engraved to the same scale, × 250 diameter. Each millimeter on the plate equals 4 μ of original dimensions.

Figures 1, 2 and 3. *Puccinia Violæ* showing three sizes of teleutospores: 1, on *V. elatior* from Germany, Sydow's Uredineen, No. 33; 2, on *V. adunca* from Gunnison, Colo.; 3, *Viola* sp. from Mexico, Holway No. 3573.

Figures 4, 5 and 6. *Puccinia Violæ* showing especially large teleutospores: 4, on *V. blanda* from Lansing, Mich.; 5 and 6, both on *V. cognata* from Sisson, Calif., taken from different sori.

Figures 7 and 8. *Puccinia Violæ* showing especially thick-walled uredospores: 7, on *V. glabella* from Bingen, Wash.; 8, on *V. primulæfolia* from Isle au Haut, Me.

Figures 9 and 10. *Puccinia effusa* showing regular and irregular spores; 9, on *V. Nuttallii* from Falcon Valley, Wash.; 10, on *V. lobata* from Dunsmuir, Calif.


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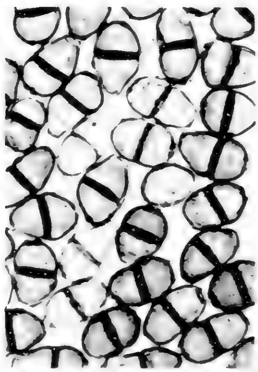
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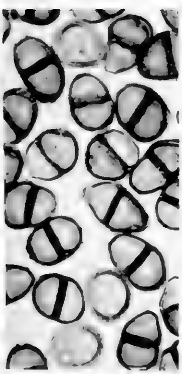
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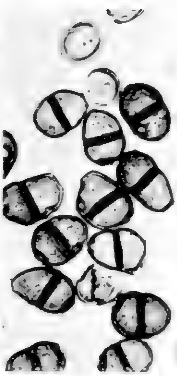
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9


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PLATE XLVII.

THE HELIOTYPE PRINTING CO., BOSTON.

XXXVIII. OBSERVATIONS ON THE EMBRYOGENY OF NELUMBO.

H. L. Lyon.

Introduction.

The peculiar and seemingly inconsistent characters of *Nelumbo* have given rise to a variety of opinions regarding its proper systematic position and in attempts to settle the points in dispute the plant has again and again been subjected to careful investigation, the recorded observations forming a considerable literature.

In anatomy the plant seems to conform more nearly to the type of the Monocotyledons, as in fact do all the Nymphæaceæ, the vascular bundles being closed and irregularly placed through the stem. On the other hand the large peltate leaves with their reticulate venation are perhaps more suggestive of a dicotyledonous plant, while the flowers might easily belong to one of either class. Thus far can investigators agree, but the anomalous character of the fruit has made it a subject for controversy, and the interpretations offered are numerous and at great variance. Briefly stated the fruit presents the following peculiarities. Each carpel of the apocarpous gynœcium contains a single ovule and matures as a spherical one-seeded fruit. The thick sclerenchymatous pericarp lined by the thin testa is closely filled by two large white fleshy bodies hemispherical in shape and joined to each other at the stigmatic end of the pericarp. In an elongated oval chamber formed by opposed concavities in the inner surfaces of these fleshy bodies, and attached to them at their point of continuity is a green structure—a stem bearing a large and small leaf and an apical bud containing two more. The free leaves are fully formed and already green and together with the stem are enclosed by a thin delicate structureless membrane. Imbedded in the common tissue of the two fleshy bodies opposite the insertion of the stem of the green structure is found a vestigial radicle. Upon the germination of the seed the fleshy bodies remain within the pericarp wall while the green structure develops into the extraseminal plant body. The radicle does not function, the first roots springing from the stem of the green structure.

The first careful description of the seed seems to have been given by Gaertner (1788, 73–74). He termed the large fleshy bodies the vitellus which he considered a transition between the endosperm and cotyledon. The green structure he considered the embryo and in *Nymphæa* he describes it as monocotyledonous, but of *Nelumbo* he says: "Ambigit Nelumbo inter plantas mono- & dicotyledones: nom ad posteriores, ex fabrica seminis, omnino spectare videtur; sed verissime ad priores pertinet, quum constantissime unicum duntaxat sub germinatione promat foliolum, nec alterum prodeat, donec prius penitus evolutum & super aqua explicatum sit:" Jussieu (1789, 68, 453) considers the green structure a monocotyledonous embryo and describes the large fleshy bodies as endosperm. Poiteau ('09, 382, 383) interprets the large fleshy bodies as cotyledons and the membrane as a stipule, but denies the presence of a radicle. Mirbel ('09) accepts Poiteau's interpretation of the large fleshy bodies but notes the presence of a radicle. Richard ('11) describes the embryo as monocotyledonous. The little sac which surrounds the green structure he considers a reduced cotyledon and the large fleshy bodies an outgrowth of the radicle. Mirbel ('15, 59, 60, *footnote*) writes: "Je ne suis pas éloigné de croire que le Piper, le Saurus———, le Nymphæa, le Nelumbo et peutêtre quelques autres genres que l'on regarde mal-a-propos comme Monocotylédons, doivent prendre place non loin les uns des autres, parmi les Dicotylédons, dans la série des familles naturelles." Mirbel's declaration seems to have settled the question as to the character of the large fleshy bodies, his interpretation having been generally accepted except by Barthélemy ('76) who asserts: (1) that the green structure is the one which arises in the embryo-sac and hence is to be considered as the embryo, (2) that the two fleshy bodies imitating cotyledons arise through the division of the exosperm.

Concerning the little colorless sac which surrounds the green structure, however, no opinion seems to have been given which could meet with general approval. In addition to those above cited De Candolle ('21) considered it a stipule, Brongniart ('27) the embryo-sac, Trecul ('54, 2) a concretion of a homogeneous substance containing numerous small, acicular crystals, and finally Wigand-Dennert ('87) in a monograph on *Nelumbium speciosum* wrote: "Es ist unzweifelhaft der Ueberrest von Endospermzellen, welche sich in der Höhlung zwischen den Cotyledonen erhalten und gleichsam auf der Oberfläche der Plumula niedergeschlagen und dadurch das Ansehen einer Membran erhalten haben."

From the above survey of literature it will be seen that modern knowledge of the seed is based on investigations made upon mature or nearly mature fruits. That alone which will determine the correct interpretation of the structures (*i. e.*, a knowledge of their origin) is entirely wanting. It was in recognition of this fact that the present embryological study was undertaken. In a preliminary note, published in *Science*, the more important conclusions were announced. 1. The embryo of *Nelumbo* is genuinely monocotyledonous in its development. The plumule arises laterally and at first there is but one cotyledon which later bifurcates to form the two fleshy bodies. 2. The membrane surrounding the plumule is, as conjectured by Wigand, a true endosperm arising within the embryo-sac.

Collection and Methods.

The material for the investigation in hand was collected by the author in August, 1899, and August, 1900, in southeastern Minnesota while working on the botanical survey of that region. There, *Nelumbo lutea* grows in great luxuriance in the sloughs and bayous of the Mississippi river, the soft muddy bottoms and quiet waters of these bayous affording an ideal habitat for the plant, where it often forms beds many acres in extent to the exclusion of other vegetation.

In collecting, each carpel was removed from the torus, the lower end cut away and the upper portion with the attached ovule placed in the fixing fluid. One-half and one per cent. chromic acid and chrom-acetic acid were used as killing reagents. The material was thoroughly washed and passed gradually into 70 per cent. alcohol in which condition it was brought into the laboratory. The ovules were imbedded in paraffine and serial sections cut with a Minot microtome. The sections were stained on the slide, a variety of stains being used; the photomicrographs and drawings, however, which accompany the present paper were made from sections stained with aniline-water-safranin or acid fuchsin.

At the present time the material at hand is insufficient for the full demonstration of certain points, especially in the development of the embryo-sac. Therefore, the present paper will be limited to a discussion of the embryogeny, the development of the embryo-sac and the cytology of reproduction being reserved for future treatment.

RESEARCH.

The embryo-sac is ovoid at its micropylar end and tapers down to a narrow attenuation which extends deeply into the nucellus. As the embryo-sac matures the nucellar tissue directly in contact with it begins to break down. There also appears in the antipodal region a club-shaped cellular structure which obliterates the lower portion of the sac (Figs. 1 and 2). The precise origin of this peculiar antipodal body remains yet to be determined. To facilitate description the embryogeny may be considered in a series of stages.

Stage A. Spherical stage.—The young embryo is usually found in the upper end of the embryo-sac among the débris resulting from the disintegration of the synergidæ. The surrounding protoplasm makes it difficult to observe the first division of the oösperm and at the present time the youngest embryo which can be described with certainty is one in the eight-celled stage represented in Fig. 3. As seen here the embryo is nearly spherical, no suspensor being evident, although there may be one present but obscured by the disorganizing synergid "a." This is not probable, however, judging from the position of the first wall in the segmenting embryo. If a suspensor cell is cut off at all, it very early loses its identity as there is no evidence of it in embryos of the age represented in Figs. 4–6. Cell division apparently takes place uniformly throughout the embryo, the result being the building up of a spherical body (Figs. 4–7). The embryo retains its spherical shape until composed of several hundred cells. At about this time the nucellar tissue in the micropylar end of the ovule has entirely broken down, so that the embryo now lies in a cavity which is bounded by the inner integument of the ovule. Simultaneously with the division of the embryonal cell the endosperm nucleus divides and the young embryo is soon surrounded by endosperm nuclei between which thin cell walls are very early apparent (Figs. 1, 4–7).

Stage B. Monocotyledonous stage.—The spherical embryo begins to evidence a maximum growth in the horizontal direction, its greater dimension being diagonal or nearly at right angles to the longer axis of the ovule. At this time it can perhaps best be described as a flattened mass or button of tissue lying in the upper end of the ovular cavity. The surface in contact with the ovular wall conforms to the shape of the latter. The free surface is more or less flattened and slightly inclined to the plane of the horizontal. The plumule (*a*, Fig. 8) now arises as a small protuberance on the inclined free surface in a median line near its lower side. The axis of the plumule is from the first about parallel with the axis of the ovule, and as it grows straight down into the ovular cavity it causes this side of the embryo, which we will term the front side, to become flattened. The future cotyledon is now evident as a crescent-shaped mound of tissue (*bb*, Fig. 8) around the rear of the embryo, its wings extending forward even with the plumule. This stage culminates in an embryo as represented in Fig. 8. The endosperm, during the monocotyledonary stage, forms a columnar mass of tissue which stands centrally in the cavity, extending from the embryo to the persistent nucellar tissue in the lower portion of the ovule.

Stage C. "Dicotyledonous" stage.—The cotyledon becomes bilobed through the localization of growth at the foci, *b* and *b*, Fig. 8. From each of these points a cotyledonary lobe grows rapidly downward outside the endosperm, the tissue of the nucellus disorganizing before it (Fig. 10). In cross section these lobes are crescent-shaped (Fig. 16) and simultaneously with their elongation growth takes place in both radial and tangential directions, each lobe at its base growing forward around the plumule. An idea of the relative positions occupied by the different structures may be derived from Figs. 13–16; cross sections of embryos which were, however, considerably older than the one represented in Fig. 9.

The growth of the plumule is slow during this stage, it being a simple dome-shaped mound of tissue (Figs. 9, 10 and 18) which comes to occupy a central position through the growing forward of the cotyledonary lobes.

At about this time the plerome first becomes apparent as a strand of somewhat smaller cells running from the plumule directly through to the base of the embryo (Figs. 12–18). From this main axis, at a point just above its middle (Fig. 18), lateral strands radiate outward and traverse the lobes of the cotyledon. This stage culminates in an embryo as represented in Fig. 9.

Stage D. Mature embryo.—This stage which is reached with the completion of intraseminal growth may be discussed under the following captions:

1. *Maturation of the Plumule.*—The first foliage leaf arises on the axis of the plumule morphologically opposite the cotyledon (*b*, Fig. 14) (*i. e.*, on the front side of the plumule axis). The second foliage leaf arises opposite the first (*c*, Fig. 19). The stipules of the first and second leaves grow over and around the apex of the stem and enclose the next two leaves, which are also preformed in the seed (Fig. 23). The lysigenous cavities of the stem and leaf petioles very early appear, as seen in Figs. 19 and 22. The structure of the mature plumule has been many times described and needs no further treatment here. Its development, however, may be well understood by a comparison of Figs. 10, 14, 17, 19, 22 and 23.

2. *Origin and Maturation of the Radicle.*—The radicle (*r*, Fig. 22) originates opposite the insertion of the plumule and is but a vestigial structure not developing into a functional primary root upon the germination of the seed. It only becomes apparent at a late stage in the development of the embryo and is usually completely enclosed by an outgrowth of the cotyledonary tissue. Fig. 24 shows a longitudinal section of the hypocotyl of a seedling which had already developed secondary roots from the epicotyl.

3. *Maturation of the Cotyledon.*—The edges of the cotyledonary lobes soon meet through tangential growth, thus forming a tube in which the plumule stands surrounded by the endosperm. The cells directly beneath the epidermis near the apex of the lobes remain densely protoplasmic and differentiate into a distinct palisade tissue (Figs. 20, 21). This undoubtedly forms a nursing area, being in contact with the lower portion of the nucellus which persists for some time and is still evident in the seed as a thicker, more distinct portion of the testa (*a*, Fig. 11). The lobes through more rapid elongation soon reach their maximum length and then by somewhat slower tangential and radial growth the embryo acquires its ultimate spherical form.

The integuments of the ovule keep pace with the growth of the embryo and form the thin testa of the seed which lines the thick pericarp.

4. *Fate of the Endosperm.*—The endosperm reaches its maximum growth early in Stage C when it forms a considerable mass of tissue lying between the lobes of the cotyledon (Fig. 16). The cell walls are never firm and offer little resistance to the growing plumule which forces its way into the center of the mass. The nuclei soon after begin to disappear and the cells to lose their definite outline. The resulting débris is crowded around the plumule by the growth of the cotyledonary lobes and is apparent in the seed as a colorless structureless sheath nearly or quite surrounding the plumule.

5. *The Embryo of the Seed.*—A carful study of the embryo of the seed without reference to its development brings to light many conditions not to be found in a dicotyledonous seed. The lobes of the cotyledon are not separate structures, but have a common tissue at the base of the embryo upon which the plumule stands (Figs. 11, 22). The sinuses between the lobes are not of equal depth, the front sinus being deeper than the rear, so that the common tissue of the lobes (*b*, Fig. 11) extends higher up in the rear of the plumule than it does in front of it. This peculiarity is even more noticeable in the seed of *N. nelumbo* than in that of *N. lutea* illustrated in the figure, and it is so distinct that it is remarkable that it has not been described before. The radicle is to a greater or less extent imbedded in tissue of cotyledonary origin, in this respect conforming to well-known monocotyledonous types.

The Embryogeny of Nelumbo Compared with That of Other Monocotyledons.

In its early development the embryo of *Nelumbo* is strikingly similar to that of *Pistia* described by Hegelmaier ('74, 681–686. *pl. 11. fig. 45–52*). The oösperm of *Pistia*, Hegelmaier finds, does not cut off a suspensor cell but by uniform divisions builds up a spherical embryo as in *Nelumbo*. The bifurcation of the cotyledon is not so inexplicable a deviation from the ordinary course of development as it may at first appear. It is rather to be considered as a modification brought about through the adaptation of the embryo to the available space within its investments.

As the embryo departs from its primitive spherical form it is evident that its axis lies more or less directly across the ovular cavity. As the plumule develops superficially near one side of this flat expanse of tissue the remaining larger surface is to be considered as that of the young cotyledon. The cotyledon soon meets obstruction to its further growth in the horizontal plane and hence turns down into the ovular cavity. Its later bifurcation is undoubtedly the result of its having to adjust itself to the cylindrical cavity in which it grows. That the shape of the cavity does to some extent affect the shape of the cotyledon seems to be evidenced by the fact that the cotyledonary lobes are at all times closely appressed to their enclosing investments. The bifurcation extends along a line of mechanical stress.

The mature embryo of *Nelumbo* can perhaps best be compared with those of the grasses, especially one having but a small amount of cotyledonary tissue below the junction of the plumule and cotyledon. The embryo of the wild rice, *Zizania aquatica*, as figured by Kennedy ('99, *pl. 3. fig. 22–24*) affords such an example. It has a long epicotyl and a very short hypocotyl which is imbedded in a small amount of cotyledonary tissue. The cotyledon grows around and nearly encloses the plumule with a uniform thickness of tissue. In *Nelumbo* the conditions are almost exactly similar, except that the cotyledon in addition to growing around the plumule has become divided lengthwise nearly to the base into two equal parts.

The Systematic Position of the Nymphæaceæ.

As indicated above the one character which has led to the placing of the Nymphæaceæ among the Dictotyledons is the structure of the embryo in the seed. In their other characters they conform more nearly to the Monocotyledons. The embryo of *Nelumbo* has been shown to be monocotyledonous in its development. Although in the other genera there is present in the seed a functional endosperm and perisperm, a careful examination of the mature embryos shows them to be in all essential respects quite similar to that of *Nelumbo*. Those common characters, then, which have previously united these plants into a family justify the conclusion that they agree in embryogeny. In order to remove all possible doubt the embryogeny of a number of Nymphæaceæ will be studied during the coming summer. The Nymphæaceæ should be classified, in the natural system, in a subseries Nymphæineæ coördinate with the Potamogetonineæ, Alismineæ and Butomineæ in the series Helobiæ.

Recapitulation and Summary.

1. *Nelumbo* both in its anatomy and embryogeny conforms to the type of the Monocotyledons.

2. The two fleshy bodies of the embryo arise through the bifurcation of the originally single cotyledon.

3. The membrane surrounding the plumule is, as conjectured by Wigand, a true endosperm arising within the embryo-sac.

4. The family of the Nymphæaceæ should be classified among Monocotyledons in the series Helobiæ.

The writer wishes to express his obligations to Professor Conway MacMillan who has carefully followed the present investigation, offering many suggestions which have been incorporated in the general discussion.

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Description of Plate XLVIII.

Figure 1. Longitudinal section of ovule containing young embryo and endosperm (×50). The nucellar tissue about the middle of the embryo-sac has broken down. The antipodal body is seen at the lower end of the sac.

2. Antipodal body (×160).

3. Eight-celled embryo (×770). (Outlined with camera lucida.) *a* = disorganizing synergid.

4, 5, 6. Longitudinal sections of ovules containing spherical embryos and endosperm (×240).

7. Cross section of ovule containing a spherical embryo closely surrounded by endosperm (×240).

8. Front view of an embryo at end of stage B. *a*=plumule, *bb*=cotyledon. This figure was reconstructed from careful micrometer measurements of serial cross sections; a proceeding found necessary in order to get the correct orientation of the embryo.

9. Front view of an embryo at end of stage C. *a*=plumule. *bb*=cotyledonary lobe. Figure obtained in same manner as Fig. 8.

10. Longitudinal section of an embryo in Stage C (×50). The endosperm is shrunken by reagents into the center of the ovular cavity.

11. A fruit with one side of the pericarp and a cotyledonary lobe cut away (×2). *a*=thicker portion of the testa. *b*=common base of the cotyledonary lobes.

Plate XLIX.

12. Cross section of the hypocotyl of an embryo just completing Stage C (×50).

13. Cross section of the same embryo through base of plumule (×50).

14. Cross section of the same embryo through apex of plumule (450). *a*=apex of stem. *b*=first leaf. *e*=endosperm.

15. Cross section of an embryo, cutting plumule a short distance above its base (×50). *e*=endosperm.

16. Cross section of same embryo through cotyledonary lobes (×50). e=endosperm.

17. Longitudinal section of an embryo early in stage D (×65). The fundament of the first leaf is already evident, also the invagination at the base of the embryo, which marks the position of the radicle.

18. Shows a sectional view of the base of an embryo in stage C. (×190).

19. Shows the plumule of a young embryo in stage D in longitudinal section (×50). *a*=apex of stem. *b*=first leaf. *c*=second leaf. *e*=endosperm. s_1 =stipule of first leaf. s_2 =stipule of second leaf.

20. Vertical section through apex of cotyledonary lobes showing differentiation of a nursing area (×50).

21. A portion of the same under a higher magnification showing the densely protoplasmic palisade tissue of the nursing area.

Plate L.

22. Longitudinal section of the plumule of the seed (×15). The first and second foliage leaves are cut off, their basal portions only showing in the figure. *r*=radicle.

23. The apical bud in the same section (×50) showing the third and fourth foliage leaves enclosed by the stipules of the first and second. *a*=apex of stem. s_1=stipule of first leaf. s_2=stipule of second leaf.

24. Longitudinal section of the hypocotyl of a seedling showing the vestigial radicle (×50).

25. Cross section through the epicotyl of a young seedling showing the adventitious roots, the first to function, (×50).

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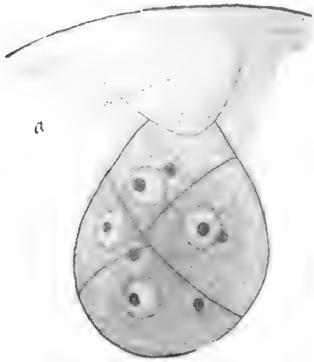

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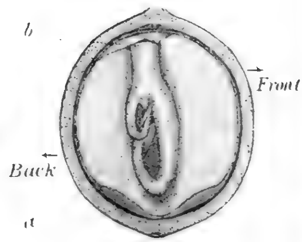

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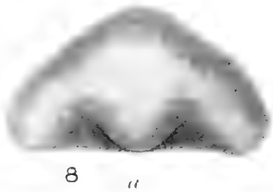

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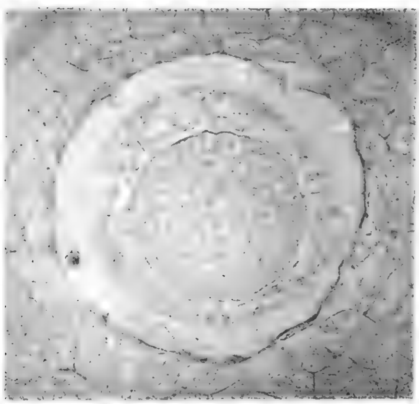

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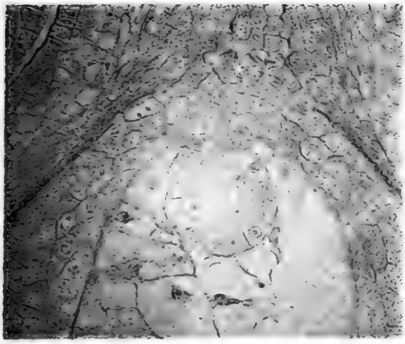

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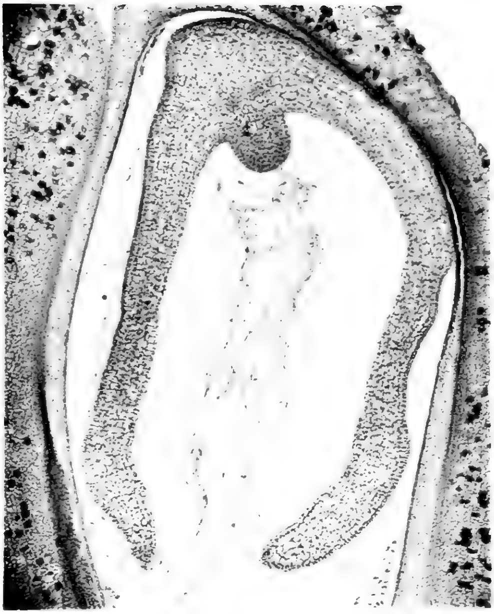

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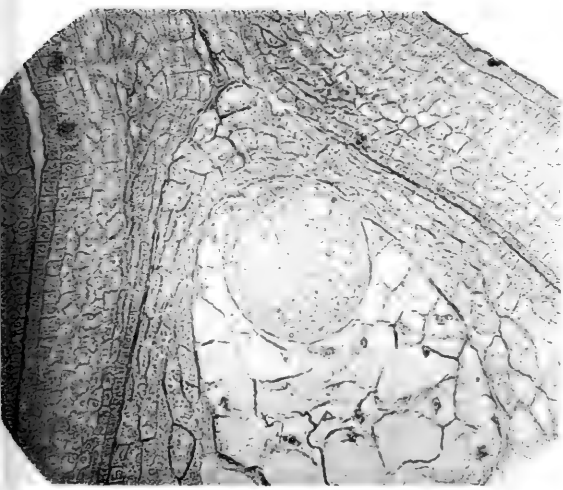

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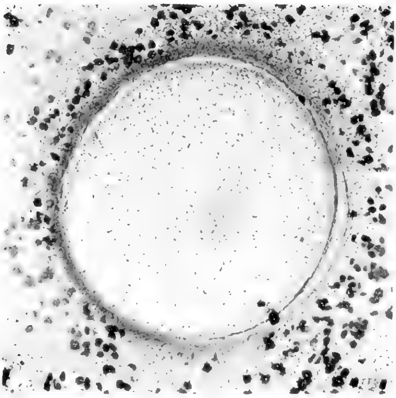

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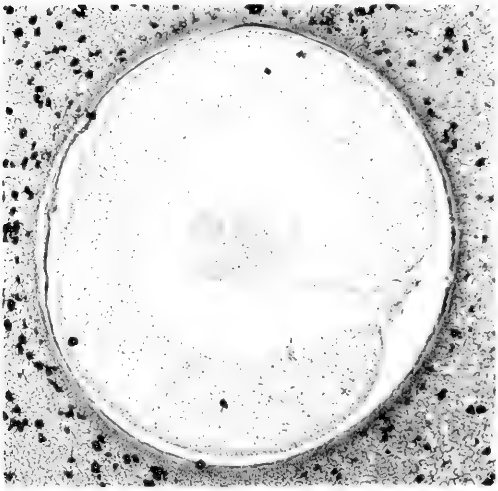

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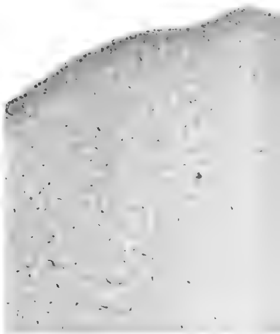

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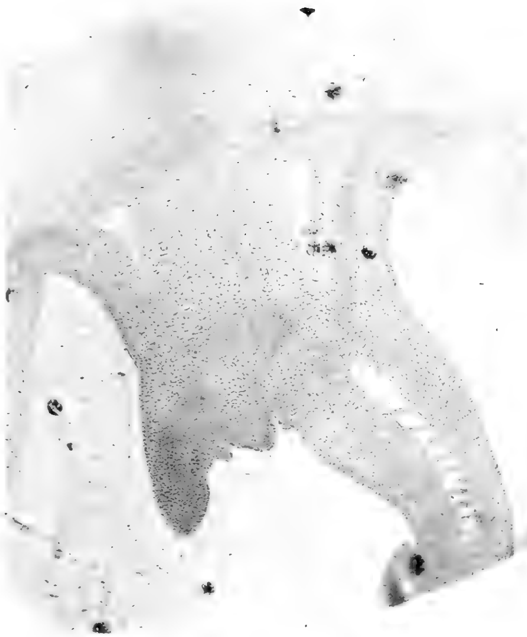
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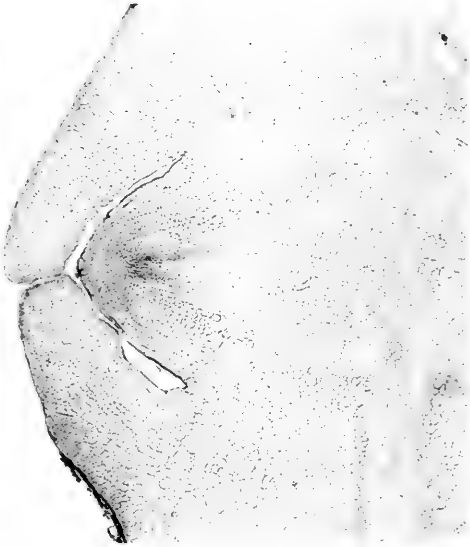

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PLATE L.

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XXXIX. CONTRIBUTIONS TO A KNOWLEDGE OF THE LICHENS OF MINNESOTA.—VI. LICHENS OF NORTHWESTERN MINNESOTA.

Bruce Fink.

CONSIDERATIONS OF DISTRIBUTION AND HABITAT.

The collections upon which this paper is based were made during the last half of June and all of July, 1900. The region traversed comprises parts of Ottertail, Beltrami and Red lake counties in northwestern Minnesota. This region was not supposed, previous to its study, to be a rich field for a lichenist, but because of its relationship to other portions of the state as to lichen flora * it seemed necessary that it should be investigated. Consequently the collection of somewhat more than 200 species as a result of the most extended collecting trip that I have yet made in Minnesota fully met my expectations as to probable results.

The itinerary was so planned as to include regions furnishing the greatest possible variety of substrata, moisture and other conditions calculated to cause variations as to lichen flora. Thus the most southern and western points reached were entirely devoid of conifers and possessed an arboreal flora quite similar to that of the southern portion of the state. These areas too were near the border between the wooded region to the east and the prairie to the west. The areas thus briefly characterized are those about Battle lake and Thief River Falls. The southern portion of the territory traversed, studied at Battle lake and Henning, gave a good view of the high morainic area of the state with its numerous rounded hills covered with granitic bowlders and calcareous soil and pebbles and possessing a scant growth of trees here and there. This southern portion was

* Fink, B. Contributions to a knowledge of the Lichens of Minnesota.—IV. Lichens of the Lake Superior Region. Minnesota Bot. Stud. 2: 234. 29 D. 1899.

also selected to furnish a connecting link with the lichen flora already studied farther south in the state. To ascertain the relationship of northwestern with northeastern Minnesota, previously studied, as to lichen flora, two regions, Bemidji and Red lake, were chosen, having an abundance of conifers and swamps. These two regions lie to the north and east of the others previously named and well within the pineries. It is to be regretted that none of the area studied possessed rock exposures of any sort, similar either to those in southern or in northern and northeastern Minnesota. These have since been reached in a study of the northern boundary of the state directly north of the area now under consideration.

The first area studied was that about Battle lake, about 150 miles northwest of Minneapolis, on the border between the wooded and prairie regions. The lichen habitats here are granitic and lime bowlders, earth and trees. The absence of rock exposures here, as well as elsewhere in the area studied during the summer, detracted much from the richness of the flora. The trees in the region about Battle lake are much the same as those about Minneapolis and in the portions of southwestern Minnesota studied in 1899. This similarity as to arboreal flora, as well as the presence of the granitic and calcareous bowlders gave a lichen flora quite similar to that of the more southern regions named above. A careful consideration of these resemblances, such as was undertaken for two regions in the second paper of this series,* would of itself lead to a long and laborious article, and must be omitted to give space for more important ecologic considerations. A noticeable feature of the lichen flora about Battle lake is that nearly all the trees growing lichens are common near the lakes and in heavy woods back from the lakes, but rare in woods back from the lakes and not heavy. All this is much like the conditions about Minneapolis, as discussed in the second paper of this series.† However, turning to the rocks, they were found literally covered with lichens even up to the very hill-tops in the morainic area south of the town. The whole number of species of lichens collected about Battle lake is 111. Comparing this with the numbers

* Fink, B. Contributions to a Knowledge of the Lichens of Minnesota.—II. Lichens of Minneapolis and Vicinity. Minn. Bot. Stud. 1: 703–716. 31 My. 1897.

† Fink, B. l. c., 705.

hitherto recorded for various well-studied localities in the state in this series of papers, we find the region slightly poorer in lichens than any other region in Minnesota having as much variety as to substrata.

The next collecting station was at Henning, about 35 miles to the northeast. This area was selected especially for the study of the flora of the Leaf hills to the south of the town and for that of the tamarack and spruce swamps, which were not found farther southwest. Prominent among the floral elements of the swamps are species of *Usnea*, *Parmelia caperata* (L.) Ach., *Parmelia saxatilis* (L.) Fr., *Alectoria jubata* (L.) Tuck. and *Cetraria ciliaris* (Ach.) Tuck. Other species will be listed toward the close of these considerations in the discussion of formations. Passing from the swamps to the Leaf hills three miles away, all of the above species become rare or entirely wanting, though the two *Parmelias* are more frequent where large trees extend, in a few places, to the tops of the morainic hills. *Rinodina sophodes* (Ach.) Nyl. and *Arthonia lecideella* Nyl., become abundant on the shrubs of oak, poplar and birch in the hills. These hills probably reach an elevation of 1,800 feet south of Vining and form the hightest morainic area in the state. The drift bowlders and pebbles of granite and limestone extend to the very summits of the hills and furnish an excellent field for the study of lichen formations, especially of granitic bowlders. The calcareous matter of the drift has been ground fine as powder or left as small pebbles. The soil contains enough lime so that the lichen formation characteristic of calcareous earth is well developed, and the limy pebbles also support a well developed calcareous rock-lichen formation. Black peak about four miles south of Vining is an especially good place for the study of the last two formations, which will receive careful consideration later in this paper. It may be noted in passing that the lichen flora of this second region is a much richer one than that first studied near the border of the wooded region, where the morainic hills are less developed, where trees are less numerous and of fewer species and where the tamarack swamps are wanting. In the region about Henning 140 species and varieties were collected in about the same time as was required to find the 111 at Battle lake.

Passing on to the next area studied at Bemidji 75 miles north of Henning and well within the pineries where there is more variety as to trees, 154 species were collected, though the calcareous formations were entirely absent and the granitic only poorly developed. The disadvantage due to absence of granitic and calcareous lichen formations seemed to be more than offset by the unusual richness of the formations of the tamarack and the cedar swamps and the earth under the pines. As this was my first opportunity for a careful study of these three formations, and the tree formations were also especially rich as well there, somewhat more time was taken for the collecting at Bemidji than elsewhere. However, notwithstanding the scarcity of any kind of bowlders and the absence of rock exposures, the Bemidji region may be regarded as one of the richest lichen floral areas in Minnesota, while Henning with its greater variety of substrata and favorable conditions is scarcely inferior.

From Bemidji I passed to Thief River Falls, about 80 miles to the northwest. Here I found a territory composed for the most part of low flat prairie, but with good woods along the banks of Red lake and Thief rivers. The trees are mostly birches, poplars, oaks and elms, forming a monotonous arboreal flora by no means favorable to the production of a large number of lichens. Inspection of the list of species and varieties recorded for this region will show that only 43 lichens were found on these trees to compare with more than twice as many on trees at Bemidji, and that these 43 are in general the most common of Minnesota lichens growing on trees. Marshes are frequent, and devoid of trees; or having the same species as grow on the higher ground, sustain no peculiar lichen species. Both granitic and lime bowlders are frequently seen in the region, but they are almost totally bare of any sort of plant life. Doubtless this is due partly to fires which frequently run over the prairies. In places pastured for several years so that fires have not occurred, lichens are beginning to take possession of the rocks. Yet it is difficult to explain the absence of lichens along high bowlder-strewn river banks, as in certain localities toward St. Hilaire, on any supposition. It will be very interesting to note the increase of lichen flora on the rocks of this region as the country becomes settled more densely and fires are kept out. In order that this may be done, I record the few lichens now occurring rarely on these rocks.

Rinodina oreina (Vill.) Mass.
Lecanora varia (Ehrh.) Nyl.

Lecanora varia (EHRH.) NYL. var. **polytropa** NYL.
Placodium murorum (HOFFM.) DC.
Placodium elegans (LINK) DC.
Physcia cæsia (HOFFM.) NYL.
Parmelia conspersa (EHRH.) ACH.

The earth lichen flora is as poorly developed as that of the trees and rocks, and the whole known lichen population of the area comprises only 78 species and varieties and is the most scanty yet studied in the state, except that at Pipestone, where trees are almost wholly absent.

The last collecting ground was at Red lake, some 65 miles east and somewhat south of Thief River Falls. This area is about 36 miles north of the one previously studied at Bemidji and has a lichen community very similar. Here the only bowlders that gave any noteworthy results were those along the lake shore, and the lichens on them were, all but three or four, of the same species as those growing upon the adjacent trees. With this dearth of rock lichens the territory, probably not quite so thoroughly studied as the one to the south about Bemidji, gave only 120 lichen species and varieties.

Compared with other portions of the state of equal size, whose lichen floras have been investigated, this one is somewhat the poorest in lichens. The number collected is little larger than that found in southwestern Minnesota, but should be considerably larger, as fully one-third more time was taken for the collecting. The Lake Superior region gave 258 lichen forms in about the same time as was spent in making the collections in northwestern Minnesota. However, this is what would be expected since the former area is more diversified as to climate, the portion near the lake having many arctic and subarctic species, while the northern and western portions yielded essentially the same species as the region now under consideration. Then too the absence of the great exposures of igneous rocks of the Superior region has already been noted for the present one, in which only 58 species and varieties of lichens, or about 28 per cent. of the whole lichen flora, were found on rocks, whereas nearly 50 per cent. of these plants in the former region were collected on the rocks. The occurrence of about three-fourths of the entire number of lichens of the whole area under consideration in one small area about Bemidji demonstrates that little of the difference in the composition of the flora of various portions of the territory is due to edaphic causes. What variety exists is due for the most part to the partial extension of the conifers, tamarack swamps and calcareous soil, bowlders and pebbles over the region.

The comparative richness of different collecting grounds as to lichen species has been noted in passing. It may be added that the number of species occurring in each place and not elsewhere found bears some relation to the whole number of species found in each area studied. Thus Battle lake with a total of 111 collected has 7 not collected elsewhere. The numbers for other collecting grounds are: Henning 140 and 18, Bemidji 154 and 31, Thief River Falls 78 and 2 and Red lake 120 and 14. Comparison of the numbers shows, as would be expected, that the number of rare lichens collected in the best collecting grounds is in much larger proportion to the total number collected than in the areas less favored as to lichen flora, where one finds only the commonest species.

Of the 41 lichen species recorded in the fourth paper of this series as arctic or subarctic,* the following seven occur in the region considered in this paper, while no new northern forms were discovered.

Ramalina pusilla (PREV.) TUCK.
Usnea cavernosa TUCK.
Stereocaulon paschale (L.) FR.
Cladonia deformis (L.) HOFFM.
Cladonia digitata (L.) HOFFM.
Biatora leucophæa (FLK.) TUCK.
Buellia petræa (FLOT., KBR.) TUCK.

The other species not new to Minnesota are in general those found farther south in the state. Thus the prediction, as to resemblance of the present flora to that farther south in Minnesota, made in the fourth paper of this series,† seems to be fairly well established, though the extreme northern boundary of the state west of the Snowbank lake area remains to be considered in the next paper. Of the genera having northern species in northeastern Minnesota, *Solorina*, *Heterothecium*, *Bæomyces* and *Umbilicaria* were not found in the area now under consideration, nor was there found more than a single genus, *Melaspilea*, new to the state. Moreover, the paucity of lichens in northwestern

* Fink, B. l. c., 227–232.
† Fink, B. l. c., 233–234.

as compared with northeastern Minnesota extends to genera as well as to species, so that 36 genera were found in the former area and 39 in the latter. This would be expected when we notice that all the seven northern species recorded above belong to genera occurring in the southern half of Minnesota, while the four genera named above as not occurring in northwestern Minnesota also have no representatives in the southern half of the state, being for the most part the most strictly northern genera thus far found in Minnesota.

The summer's collecting brought to light 48 species and varieties new to the state, of which 9 are new to North America and 3 new, while another 3 are yet undetermined. The discovery of so large a proportion of new material nearly one-fourth of all species collected, after other parts of the state had been for the most part, well studied, is somewhat of a surprise, and seems to indicate that there is yet a good number of lichens to be found in Minnesota. As to forms new to North America, this paper adds a larger number than all the previous lists published for the state.

The genus *Calicium* deserves special mention because of the interesting facts disclosed when the material collected was carefully studied. Previously nine species and varieties had been recorded for the state, and though the genus is not an arctic or subarctic one, I had not expected to find it well represented in territory otherwise closely related to the southern half of Minnesota as to lichen population. Consequently, I was not a little surprised to find ten species in my collection, one more than had hitherto been reported for the state, and yet more when I found that six of the species were new to the state, thus raising the number of *Caliciums* in Minnesota to 15 species and varieties. We now have found within the state about half of the forms of the genus recorded for North America, and *Calicium* can no longer be regarded as a genus peculiar to the Atlantic region. The cause of the extension of members of the genus into a region closely related with southern Minnesota as to lichen flora is to be found in the circumstance that the *Caliciums* seem to follow the conifers regardless of slight climatic changes. While some other genera furnish each a few species new to the state, or not found further south in Minnesota, there is nothing especially noteworthy about the distribution of any of them, as the species are in general such as could be expected to occur farther south, and may have been overlooked.

It now remains to follow out the ecologic study begun in the fifth paper of this series,* pursuing the general plan of study introduced there. First of all I shall consider some of the formations therein recorded and draw some comparisons. As in the former paper I shall consider especially the more common lichens, which give character to the flora and lichen formations of the state. Beginning with the lichen formation of the exposed granitic bowlders about Battle Lake, the formation may be designated as follows:

LECANORA LICHEN FORMATION OF EXPOSED GRANITIC BOWLDERS (BATTLE LAKE).

Physcia stellaris (L.) Tuck. var. apiola Nyl., C.
Physcia cæsia (Hoffm.) Nyl., CX.
Placodium elegans (Link.) DC., C.
Placodium cinnabarrinum (Ach.) Anz., C.
Placodium aurantiacrm (Lightf.) Naeg. and Hepp., B.
Placodium cerinum (Hedw.) Naeg. and Hepp., B.
Placodium cerinum (Hedw.) Naeg. and Hepp. var. sideritis Tuck., CX.
Placodium vitellinum (Ehrh.) Naeg. and Hepp., CX.
Lecanora rubina (Vill.) Ach., CX.
Lecanora muralis (Schreb.) Schaer. var saxicola Schaer., C.
Lecanora hageni Ach., C.
Lecanora varia (Ehrh.) Nyl., B.
Lecanora varia (Ehrh.) Nyl. var. polytropa Nyl., B.
Lecanora cinerea (L.) Sommerf., CX.
Lecanora calcarea (L.) Sommerf. var. contorta Fr., C.
Lecanora xanthophana Nyl., CX.
Lecanora cervina (Pers.) Nyl., C.
Lecanora fuscata (Schrad.) Th. Fr., C.
Rinodina oreina (Ach.) Mass., C.
Rinodina sophodes (Ach.) Nyl., CX.
Rinodina sophodes (Ach.) Nyl. var. exigua Fr., B.
Buellia pullata Tuck., C.
Buellia petræa (Flot., Kbr.) Tuck., CX.
Buellia petræa (Flot., Kbr.) Tuck. var. montagnæi Tuck., C.

* Fink, B. Contributions to a Knowledge of the Lichens of Minnesota.—V. Lichens of the Minnesota Valley and Southwestern Minnesota. Minn. Bot. Stud. 2: 283–308. 29 D. 1899.

This formation may be compared est with the si milar one upon the exposed granite at Granite Falls.* As might be expected the Battle lake formation confined to the bowlders suffers somewhat in comparison with that at Granite Falls, which is developed upon extensive exposures of granite. The number of lichens in the formation at the former place is 24 and the number at the latter 31. Species common to the two similar formations I have marked (C), and those found at Battle lake only are marked (B). Of the ten species found at Granite Falls and not at Battle lake, *Parmelia conspersa* (Ehrh.) Ach. deserves special mention as being unaccountably rare in the region covered by this paper. The entire absence of another of the ten, *Biatora rufonigra* Tuck., from the region is quite as remarkable. The other eight are lichens either not widely distributed in the state, or not common on granitic rocks. Eight of the species of the formation recorded above have occurred in all of the four localities in the state in which similar formations have been recorded. These may be considered the most constant elements of such formations in Minnesota, and I have marked them (X). The formation is also well developed in the Leaf hills, but nothing would be gained by recording it.

As to the general character of the lichens of the formation, all but the first three and the first *Lecanora* are strictly crustaceous, and this last plant, as well as the foliaceous *Placodium*, is nearly as closely adnate to the substratum as the crustaceous forms. The less adnate foliaceous species have a well-developed cellular cortex on all sides for support and for protection against too rapid evaporation of moisture in their exposed and dry habitat. Of the crustaceous species, the *Placodiums* have good upper and some of them a lower cortex, the *Lecanoras* have either an upper only or none, while the *Rinodinas*, except possibly the first, have no cortical layers; and the last statement applies to the *Buellias* as well. The forms, having no cortex or a poorly-developed one and growing in such a dry, exposed habitat, have very small thalli. A large foliaceous lichen with no cortex, as a *Collema* for instance, could hardly exist in the present formation. Finally the lichens of the formations are a few foliaceous species with well-developed cortex above and below, but still quite closely adnate, and a much larger number with no cortex or an upper one only, but having

* Fink, B. l. c., 286, 287.

very small thalli, and though epilithic yet very closely adnate, so that moisture easily passes into them from the rocky substratum below.

Next may naturally follow the mixed lichen formation of shaded granitic bowlders.

MIXED LICHEN FORMATION OF SHADED GRANITIC BOWLDERS (RED LAKE).

A. Probably naturally belonging to the rocks.

Biatora inundata Fr.
Verrucaria nigrescens Pers.
Verrucaria viridula Ach.
Verrucaria muralis Ach.

B. Near trees and probably migrated from them.

Theloschistes lychneus (Nyl.) Tuck., C.
Parmelia borreri Turn., C.
Parmelia saxatilis (L.) Fr., C.
Parmelia olivacea (L.) Ach.
Parmelia caperata (L.) Ach., C.
Physcia speciosa (Wulf., Ach.) Nyl., C.
Physcia pulverulenta (Schreb.) Nyl., C.
Physcia stellaris (L.) Tuck.
Physcia stellaris (L.) Tuck. var. apiola Nyl.
Physcia astroidea (Fr.) Nyl.
Physcia hispida (Schreb., Fr.) Tuck.
Physcia obscura (Ehrh.) Nyl., C.

Of the 12 species of the formation probably having migrated from trees near by, seven marked (C) are common to all of the six similar formations studied in the state,* but none of the four elements naturally belonging to the rocks are common to the similar formations.

Comparing these lichens with those of the exposed rock formation above, we find an entirely different type of thallus to prevail, viz., the foliaceous type of the *Parmelias* and *Physcias* with thalli having well developed cortical layers. And as would be expected in an ombrophytic lichen formation having such thalli, the plants are not so closely adnate to the substratum as those of the exposed rock formation, but are

* Fink, B. l. c., 290–293.

more loosely attached by rhizoids. However, those undoubtedly belonging to the rocks have poorly developed thalli with no cortex or an upper pseudo-cortex, and *Verrucaria muralis* Ach., an intruder usually growing upon calcareous rocks in exposed places, is essentially hypolithic. That the three forms having poorly developed and epilithic thalli should seek ombrophytic associations is, of course, natural enough.

The *Cladonia-Peltigera* formation of shaded earth was found remarkably well developed under the pines at Bemidji. The table of species below shows 20 forms. The formation here, though containing the same genera as the similar one farther south,* is twice as well developed, being especially rich in *Cladonias*, which flourish under the pines. I have marked (C) the five species common to the similar formations noted for the state, as being the most constant elements of such formations, at least in Minnesota. I shall now record the formation and follow with a discussion of structure of the lichens composing it.

CLADONIA-PELTIGERA LICHEN FORMATION OF SHADED EARTH (BEMIDJI).

Peltigera horizontalis (L.) HOFFM.
Peltigera canina (L.) HOFFM., C.
Peltigera canina (L.) HOFFM. var. **spuria** ACH.
Peltigera canina (L.) HOFFM. var. **sorediata** SCHAER., C.
Collema pulposum (BERNH.) NYL., C.
Collema limosum ACH.
Collema crispum BORR.
Cladonia cariosa (ACH.) SPRENG.
Cladonia pyxidata (L.) FR., C.
Cladonia degenerans FLK.
Cladonia gracilis (L.) NYL., C.
Cladonia gracilis (L.) NYL. var. **symphycarpia** TUCK.
Cladonia gracilis (L.) NYL. var. **verticillata** FR., C.
Cladonia gracilis (L.) NYL. var. **elongata** FR.
Cladonia gracilis (L.) NYL. var. **hybrida** SCHAER.
Cladonia cornuta (L.) FR.
Cladonia furcata (HUDS.) FR.
Cladonia rangiferina (L.) HOFFM.
Cladonia rangiferina (L.) HOFFM. var. **alpestris** L.
Cladonia uncialis (L.) FR.

* Fink, B. l. c., 294–295.

Comparing the lichens of this formation with those of the shaded rock formation above, we find that, as a result of the more moist habitat of the forms, growing on earth in shade and usually on an abundance of decaying vegetable remains which hold moisture, the formation consists of plant individuals even less closely attached to the substratum, except perhaps the *Collemas*, which have no cortex and which, therefore, even in their shaded situation, remain close to the substratum to absorb the moisture which is rapidly evaporated from their non-cellular surfaces. The *Peltigeras* with a well developed upper cortex hold moisture better and rise somewhat higher. The podetia of the *Cladonias* have a surrounding pseudo-cortex of densely interwoven hyphæ, which serves for protection against too rapid evaporation of moisture as well as for mechanical support. Hence the *Cladonias* rise vertically and are especially numerous as to species and individuals in this moist and shaded formation, as well as unusually luxuriant. Thus it appears that we have in this formation, as in those already considered plants adapted in very different ways to the environment.

The remarkable constancy of occurrence of certain floral elements in certain environments can scarcely be better illustrated than by comparing the calcareous earth lichen formation given below with similar ones recorded in the fifth paper of this series for Granite Falls, Minnesota, and Fayette, Iowa.*

BIATORA DECIPIENS LICHEN FORMATION OF EXPOSED CALCAREOUS EARTH (LEAF HILLS).

Heppia despreauxii (MONT.) TUCK., C.
Urceolaria scruposa (L.) NYL., C.
Biatora decipiens (EHRH.) FR., C.
Biatora decipiens (EHRH.) FR. var. **delabata** AUCT., C.
Biatora muscorum (SW.) TUCK., C.
Endocarpon hepaticum ACH., C.

All of the six floral elements recorded in the present formation and marked (C) are also listed in the formation at Granite Falls and Fayette, and each of these last two contains a single rare species not discovered in the Leaf hills formation. As in the localities previously studied, the formation in the hills is best developed on the hill-sides where the plants are washed with the lime-impregnated water which flows down the slope during

* Fink, B. l. c., 295-296.

rains, and it may be regarded as well established that such a sloping surface is best adapted to the development of the formation.

As to structural adaptations to an exposed and usually dry habitat, the lichens of the formation all have small thalli and are closely adnate. The rudimentary thallus of *Biatora muscorum* (Sw.) Tuck. has no cortex, and the somewhat better developed one of the *Urceolaria* has only a poorly developed pseudo-cortex above. Of the larger and better developed thalli, that of *Biatora decipiens* (Ehrh.) Fr. has a very heavy cellular cortex above, the *Endocarpon* has a well-developed cortex on all sides while the *Heppia* is cellular throughout. In these larger thalli growing in exposed dry places, the cellular areas serve of course not only for support, but also for protection of the algæ within and against excessive evaporation; nor must it be supposed that any of these thalli are large for a really large thallus is seldon seen in such a formation, and if present at all, should be considered an accident in plant distribution not to be recorded. The four better developed thalli are then only large in comparison with the other two and average about 3 to 6 mm. in diameter. The two rudimentary thalli of the formation are able to persist because very small and closely adnate.

Comparing next the lichen formation of the calcareous pebbles of the same area with the same two for the Minnesota and Iowa localities used above,* we find that the adding of another Minnesota locality still leaves the same five species common (C) to such formations for the two states. This third formation of the kind recorded below, establishes a general resemblance of such formations in widely separate localities.

LECANORA CALCAREA CONTORTA LICHEN FORMATION OF EXPOSED LIMESTONE (LEAF HILLS).

Placodium vitellinum (Ehrh.) Naeg. and Hepp. var. **aurellum** Ach., C.

Lecanora muralis (Schreb.) Schaer. var. **versicolor** Fr.

Lecanora subfusca (L.) Ach.

Lecanora calcarea (L.) Sommerf. var. **contorta** Fr., C.

Lecanora privigna (Ach.) Nyl., C.

Lecanora privigna (Ach.) Nyl. var. **pruinosa** Auct.

Rinodina bischoffii (Hepp.) Kbr.

* Fink, B. l. c., 297

Endocarpon pusillum HEDW., C.
Verrucaria nigrescens PERS.
Verrucaria muralis ACH., C.

The lichens of the above formation have small thalli, closely adnate or even more or less strictly hypolithic. All except the last *Verrucaria*, which is hypolithic, and *Lecanora privigna* (Ach.) Nyl., which has a very rudimentary and evanescent thallus have more or less of a cellular or pseudocellular cortex above. None except the first *Lecanora*, which has the largest thallus in the formation, showed any indication of such structure below. The upper cortex gives these better developed but still small thalli sufficient protection against evaporation and adapts them to their dry station.

The lichen formation for trees with rough and smooth bark at Bemidji are in general quite like the corresponding ones recorded for Mankato and Granite Falls,* but are rather richer in species. I record them below as they may be of use in the further study of the lichens of northern Minnesota.

PARMELIA LICHEN FORMATION OF TREES WITH ROUGH BARK (BEMIDJI).

Ramalina calicaris (L.) FR. var. **fastigiata** FR.
Ramalina calicaris (L.) FR. var. **fraxinea** FR.
Usnea barbata (L.) FR. var. **florida** FR.
Theloschistes chrysopthalmus (L.) NORM.
Theloschistes polycarpus (EHRH.) TUCK.
Theloschistes lychneus (NYL.) TUCK.
Theloschistes concolor (DICKS.) TUCK.
Theloschistes concolor (DICKS.) TUCK. var. **effusa** TUCK.
Parmelia crinita ACH.
Parmelia borreri TURN.
Parmelia tiliacea (HOFFM.) FLK.
Parmelia saxatilis (L.) FR.
Parmelia saxatilis (L.) FR. var. **sulcata** NYL.
Parmelia olivacea (L.) ACH.
Parmelia olivacea (L.) ACH. var. **sorediata** (ACH.) NYL.
Parmelia caperata (L.) ACH.
Physcia speciosa (WULF., ACH.) NYL.
Physcia hypoleuca (MUHL.) TUCK.

* Fink, B. l. c., 302-305.

Physcia pulverulenta (Schreb.) Nyl.
Physcia stellaris (L.) Tuck.
Physcia hispida (Schreb., Fr.) Tuck.
Physcia obscura (Ehrh.) Nyl.
Collema pycnocarpum Nyl.
Collema flaccidum Ach.
Collema nigrescens (Huds.) Ach.
Leptogium myochroum (Ehrh., Schaer.) Tuck.
Placodium aurantiacum (Lightf.) Naeg. and Hepp.
Placodium cerinum (Hedw.) Naeg. and Hepp.
Lecanora subfusca (L.) Ach.
Lecanora varia (Ehrh.) Nyl.
Lecanora verrucosa (Ach.) Laur.
Pertusaria finkii A. Zahlb.
Biatora turgidula (Fr.) Nyl.
Biatora arthropurpurea (Mass.) Hepp.
Biatora rubella (Ehrh.) Rabenh.
Biatora fuscorubella (Hoffm.) Tuck.
Biatora atrogrisea (Delis.) Hepp.
Lecidea enteroleuca Fr.
Buellia alboatra (Hoffm.) Th. Fr.
Buellia parasema (Ach.) Th. Fr.
Opegrapha sp.
Graphis scripta (L.) Ach.
Graphis scripta (L.) Ach. var. limitata Ach.
Graphis scripta (L.) Ach. var. recta (Humb.) Nyl.
Arthonia lecideella Nyl.
Calicium lucidum (Th. Fr.) Fink.
Coniocybe pallida (Pers.) Fr.
Melaspilea arthonioides (Fée) Nyl.
Pyrenula leucoplaca (Wahl.) Kbr.
Pyrenula leucoplaca (Wahl.) Kbr. var. pluriloculata var. nov.

I shall now record the smooth bark formation and then consider the adaptations of the two groups together.

PYRENULA FORMATION OF TREES WITH SMOOTH BARK (BEMIDJI).

Theloschistes polycarpus (Ehrh.) Tuck.
Theloschistes concolor (Dicks.) Tuck.
Parmelia olivacca (L.) Ach.
Placodium cerinum (Hedw.) Naeg. and Hepp.

Lecanora subfusca (L.) Ach.
Lecanora varia (Ehrh.) Nyl.
Rinodina sophodes (Ach.) Nyl.
Biatora atropurpurea (Mass.) Hepp.
Biatora rubella (Ehrh.) Rabenh.
Lecidea enteroleuca Fr.
Buellia parasema (Ach.) Th. Fr.
Graphis scripta (L.) Ach.
Arthonia lecideella Nyl.
Arthonia radiata (Pers.) Th. Fr.
Sagedia oxyspora (Nyl.) Tuck.
Pyrenula punctiformis (Ach.) Naeg. var. **follax** Nyl.
Pyrenula cinerella (Flot.) Tuck. var. **quadriloculata** Fink.
Pyrenula leucoplaca (Wahl.) Kbr.
Pyrenula leucoplaca (Wahl.) Kbr. var. **pluriloculata** var. nov.

Inspection of the list of plants given above for the rough bark formations based on characters of substratum, shows lichens varying widely structurally and adapted to the formation in very different ways. There are the *Biatoras*, which usually occur in the more moist and shaded spots in this scattered formation and have small thalli usually without cellular cortex. The same may be said of the *Buellias* and the *Acolium*, while the *Lecanoras*, *Placodiums*, and *Pertusarias* usually have somewhat larger thalli and some indication of an upper cortex at least. Even more rudimentary than any of the above are the thalli of the *Opegraphas*, *Graphies*, *Pyrenulas* and the *Coniocybe* which are hypophlœodal and thus protected. However the *Collemas* without cellular cortex rise to the foliaceous type, but seek very damp and well shaded habitats. The *Leptogium*, with upper cortex only, seeks damp places also. Next may be considered the *Theloschistes*, *Parmelias* and *Physcias* with foliaceous thalli having good cortex on all sides, and which are not so closely adnate to the substratum as the crustaceous forms. Finally we have the fruticulose type of structure represented in the formation in the *Ramalinas* and *Usneas*. These plants have a good cortex on all sides though not cellular at least in the first genus, and in well shaded and moist portions of the formation are quite common. This formation furnishes the most variety as to methods of adaptation of any herein recorded.

The lichens composing the smooth bark formation are not so various in type, including only the more crustaceous and rudimentary types of those given above. The more developed forms with more specialized rhizoids usually fail to gain a foothold on the smooth bark.

Next in order may be considered the formation of old wood.

CALICEI LICHEN FORMATION OF DEAD WOOD (BEMIDJI).

Placodium cerinum (HEDW.) NAEG. and HEPP. var. **pyracea** NYL., C.
Placodium ferrugineum (HUDS.) HEPP.
Lecanora varia (EHRH.) NYL., C.
Lecanora varia (EHRH.) NYL. var. **sæpincola** FR.
Lecanora varia (EHRH.) NYL. var. **symmicta** ACH.
Rinodina sophodes (ACH.) NYL., C.
Biatora uliginosa (SCHRAD.) FR.
Lecidea enteroleuca FR. var. **ambigua** ANZ.
Buellia parasema (ACH.) TH. FR., C.
Buellia myriocarpa (DC.) MUDD.
Acolium tigillare (ACH.) DN.
Calicium lucidum (TH. FR.) FINK.
Calicium sp.
Calicium trabinellum (SCHAER.) KBR.
Calicium parietinum ACH.
Calicium trichiale ACH. var. **cinereum** NYL.

This formation is given a slightly different designation from the similar ones previously recorded for Mankota and Granite Falls * because of the absence of old boards in the new country about Bemidji. The formation recorded in this paper is similar to the two formerly recorded, but much richer, especially in *Calicei*, for which group the formation is named. Yet the three *Calicei* formations recorded for the state show more variation than other related formations and have only four (C) common species of a total of 23. Moreover, not a single member of the *Calicei* is common to the three formations. From some hasty observations made in 1897 in the Lake Superior region,† I had come to believe that certain *Caliciums* normally grow on rotting wood. Careful observation in 1900 showed that all

* Fink, B. l. c., 305–306.
† Fink, B. l. c., 306.

found during that summer at least belong to living or to dead wood formations though occasionally the plants on dead wood may persist after the wood has begun to decay perceptibly at the surface.

The lichens of this formation are of the small, closely adnate or hypophœodal crustaceous type with upper cortical protection in the *Lecanoras* and *Placodiums* and none in the *Rinodina*, the *Lecidea*, the *Buellias* and the *Caliciums*. The substratum is a dry one usually, as I have not concluded the more damp and more frequently rotting logs of the tamarack swamps, which have their own peculiar formation recorded below. Hence, the crustaceous type of thallus is especially adapted to the formation. True the *Caliciums* put up the minute erect podetia, but these are solid cylinders of hyphæ running in a longitudinal direction and usually quite devoid of the algal symbionts which might suffer from dryness.

The last of the formations to be compared with those studied in 1897 in southwestern Minnesota is the following.

CLADONIA LICHEN FORMATION OF ROTTEN WOOD (BEMIDJI).

Peltigera canina (L.) HOFFM., C.
Peltigera canina (L.) HOFFM. var. **sorediata** SCHAER.
Cladonia mitrula TUCK.
Cladonia pyxidata (L.) FR.
Cladonia pyxidata (L.) FR. var. **neglecta** (FLK.) MASS.
Cladonia fimbriata (L.) FR. var. **tubæformis** FR., C.
Cladonia fimbriata (L.) FR. var. **simplex** (WEIS.) FLOT.
Cladonia gracilis (L.) NYL., C.
Cladonia gracilis (L.) NYL. var. **hybrida** SCHAER.
Cladonia gracilis (L.) NYL. var. **symphycarpia** TUCK.
Cladonia gracilis (L.) NYL. var. **verticillata** FR., C.
Cladonia gracilis (L.) NYL. var. **anthocephala** FLK.
Cladonia macilenta (EHRH.) HOFFM.
Cladonia bacillaris NYL.
Cladonia cristatella TUCK.

Comparing this formation with the corresponding ones at Mankato and Granite Falls,* we find that the formations are constant at least as regards genera, the one herein recorded for a region, especially rich in *Cladonias*, being of course richer in species than the two formerly studied. The addition of a third

*Fink, B. l. c., 306-307.

locality has only diminished the number of common species (C) by one. Like the very similar *Cladonia-Peltigera* formation recorded above, this one is especially developed under the pines. Indeed, it hardly seems necessary to separate them in the region now under consideration.

The adaptations of the plants of the formation are similar to those fully discussed under the *Cladonia-Peltigera* formation. Briefly then, the *Peltigeras*, having only an upper cellular cortex, lie flat on the substratum, while the *Cladonias*, protected on all sides by a pseudo-cortex, rise vertically and become luxuriant in the moist and shaded habitat.

Next in order I shall consider a number of formations somewhat studied in the Lake Superior region in 1897, but not yet recorded for the state, as it was then found impossible to take sufficient data in the rapid survey of a region fully one fourth of whose lichen flora the writer had previously known only through herbarium specimens or not at all. In the second survey of a somewhat similar region, I was able to take sufficient field notes upon which to base an ecologic study of lichen formations peculiar to the region as well as those previously known. These formations, new to the state, will be recorded for more than one place as far as possible.

First of all I shall record the formation of the pine trees, naming it for the *Usnei* group which give character to this plant community:

USNEI LICHEN FORMATION OF THE PINES (RED LAKE).

Cetraria ciliaris (ACH.) TUCK. (cones).
Cetraria juniperina (L.) ACH. var. **pinastri** ACH.
Evernia prunastri (L.) ACH. (cones).
Usnea barbata (L.) FR. var. **florida** FR.
Alectoria jubata (L.) TUCK. var. **chalybeiformis** ACH.
Theloschistes chrysopthalmus (L.) NORM.
Parmelia physodes (L.) ACH.
Physcia tribacia (ACH.) TUCK.
Physcia hispida (SCHREB., FR.) TUCK.
Lecanora varia (EHRH.) NYL. (cones).
Lecanora subfusca (L.) ACH. var. **argentata** (ACH.) (cones).
Buellia parasema (ACH.) TH. FR. (cones).
Calicium lucidum (TH. FR.) FINK.

On approaching a pine woods one is impressed with an apparent dearth of lichens, but after a careful study he becomes convinced that the plants are common enough when the trees, the fallen branches and the earth are carefully observed. The foliaceous *Parmelias*, *Physcias*, etc., so common on the deciduous trees, are not so frequently seen, but the pines certainly have their own peculiar formations, composed of lichens found of course on other substrata in various parts of the state. The variety of *Cetraria juniperina* (L.) Ach. and the *Calicium lucilium* (Th. Fr.) Fink are perhaps the most characteristic elements of the formation, as they are seldom seen elsewhere than on the conifers, though by no means common even in this formation. The similar formation was studied at Bemidji, and the only difference is that *Lecanora subfusca* (L.) Ach. replaces the variety. As indicated in the list of species, a number of the plants are as common or more so on the old cones as on other portions of the trees. Careful comparison of this formation with the *Parmelei* formation of trees with rough bark will demonstrate that the two are quite distinct, though resembling each other in some respects.

The adaptations of the lichens of this formation are somewhat various. They have been discussed somewhat under the rough bark formation above and will be further noticed under the *Usnea* formation below. However, while it is apparent that the fruticulose lichens of the *Usnei* group seem well adapted to the swamp *Usnea* formation given below where moisture is abundant, I have not been able to satisfy myself that the pines of the higher ground furnish more moisture than the deciduous trees of similar grounds. I suspect that the plants in this instance and in the formation given below for the swamps are quite as much influenced in their choice of habitat by an adaptation to coniferous wood as by amount of moisture. And I may add here that in other portions of this paper I have not taken into account any adaptations of the lichens to substrata of certain physical or chemical composition. The subject is a difficult one as yet little understood, and moreover I am convinced from observation that, beyond the well-known fact that some lichens prefer rocks, calcareous in some instances and granitic, etc., in others, while others prefer trees and in some instances a particular species or genus, the conditions as to shade, moisture, etc., are the important ones in determining the habitats of lichens and the composition of lichen formations.

I studied the lichens of the earth and rotting wood under the pines with a view to establishing a formation; but the plants were found to be so similar to those of the *Cladonia* lichen formation of rotten wood and the *Cladonia-Peltigera* lichen formation of shaded earth previously established that I have recorded them above in these formations, though possibly I have done violence in not separating them in this region for the sake of correlating results with former work in another area.

Because of close relationship to the above formation, I shall next consider the *Usnea* formation.

USNEA LICHEN FORMATION OF TAMARACKS IN SWAMPS (HENNING).

Cetraria ciliaris (ACH.) TUCK., C.
Evernia prunastri (L.) ACH., C.
Usnea barbata (L.) FR. var. **florida** FR., C.
Usnea barbata (L.) FR. var. **ceratina** SCHAER.
Usnea barbata (L.) FR. var. **dasypoga** FR.
Usnea cavernosa TUCK., C.
Alectoria jubata (L.) TUCK. var. **chalybeiformis** ACH., C.
Parmelia physodes (L.) ACH., C.
Parmelia olivacea (L.) ACH., C.
Parmelia caperata (L.) ACH., C.
Physcia hispida (ACH.) TUCK., C.
Calicium trichiale ACH. var. **cinereum** NYL.

The formation was afterward carefully examined at Bemidji and Red lake and was found to be a very characteristic one. At Bemidji were found all of the above-marked (C) and *Ramalina pusilla* (Prev.) Tuck., *Cetraria juniperina* (L.) Ach. var. *pinastri* Ach., *Alectoria jubata* (L.) Tuck. and *Calicium chrysocephalum* Ach. in addition. The Red lake formation contained all of the species found at Bemidji except the last two, so that those marked (C) are the ones common to the three similar formations.

The dominant elements in this formation are the *Usneas*, the *Evernia* and the *Alectoria*, which in the moist swamps and protected on all sides by a pseudo-cortex of closely arranged hyphæ, hang suspended or grow up from the substratum in fruticulose fashion. With these occur the less characteristic elements whose structure has been fully discussed and whose adaptations may be easily inferred. Though, as stated in the discussion of the *Usnei* formation of the pines, the plants may be adapted to the coniferous wood as well as to the moist habitat, it remains to be stated that the same species are both more numerous and more luxuriant in the swamps than on the upland pines.

The following formation must be regarded as somewhat doubtful till further studied.

STICTA PULMONARIA LICHEN FORMATION OF CEDAR SWAMPS (BEMIDJI).

Sticta pulmonaria (L.) Ach.
Nephroma lævigatum Ach.
Lecanora pallida (Schreb.) Schaer.
Lecanora pallescens (L.) Schaer.
Pertusaria communis DC.
Calicium chrysocephalum Ach.

There is no doubt of the distinctness of the formation in the region as none of the plants were found elsewhere during the summer than in the cedar swamps, except the last which was also found in the tamarack swamps. The plants of the formation grow in dryer places in other regions and seem to be as well adapted to upland woods as many other lichens recorded for the tree formations of higher ground.

The swamps afford yet one other characteristic formation well developed in the area studied wherever tamaracks and cedars flourish. It may appropriately be designated as follows:

THE CALICIUM LICHEN FORMATION OF OLD LOGS AND STUMPS IN TAMARACK SWAMPS (HENNING).

Ramalina pusilla (Prev.) Tuck., C.
Cetraria ciliaris (Ach.) Tuck., C.
Parmelia saxatilis (L.) Fr., C.
Cladonia mitrula Tuck., C.
Cladonia fimbriata (L.) Fr. var. **tubæformis** Fr., C.
Cladonia gracilis (L.) Nyl., C.
Cladonia gracilis (L.) Nyl. var. **hybrida** Schaer., C.
Calicium trichiale Ach. var. **cinereum** Nyl., C.
Calicium trachelinum Ach.
Calicium sp.
Calicium curtum Turn. and Borr.

Calicium trabinellum (SCHAER.) KBR.

Calicium parietinum ACH.

The similar formations were studied at Bemidji and Red lake, and the species marked (C) were found in each of the three formations. For Bemidji may be added *Biatora viridescens* (Schrad.) Fr. and for both Bemidji and Red Lake, *Cetraria juniperina* (L.) Ach. var. *pinastri* Ach. Although occurring in the same area as the second formation above on the living tamaracks, the present one will be found by comparison to be quite distinct both as to genera and species.

Growing in moist areas, the lichens of the formation are almost uniformly those which rise more or less from the substratum. Nearly all are the *Cladonias* and *Caliciums*, which have podetia rising erect from the substratum and are protected on all sides by a pseudo-cortex of densely interwoven hyphæ running in a longitudinal direction.

The earth lichen formations of the swamps were carefully noted and were found to be essentially like those of *Cladonia* formations of rotten wood recorded above, at least as to genera. I shall record the formation provisionally that it may be further studied and shall name it for a variety of *Peltigera* thus far found in the state only in the swamps.

PELTIGERA CANINA LEUCORRHIZA LICHEN FORMATION OF EARTH IN TAMARACK SWAMPS (BEMIDJI).

Peltigera canina (L.) HOFFM., C.

Peltigera canina (L.) HOFFM. var. **leucorrhiza** FLK., C.

Cladonia cariosa (ACH.) SPRENG., R L.

Cladonia pyxidata (L.) FR., C.

Cladonia gracilis (L.) NYL. var. **verticillata** FR., C.

Cladonia gracilis (L.) NYL. var. **hybrida** SCHAER., C.

Cladonia cenotea (ACH.) SCHAER., R L.

Cladonia furcata (HUDS.) FR., B and H.

Cladonia rangiferina (L.) HOFFM., C.

The similar formations were studied at Henning and Red lake. Those marked (C) are common to the three formations, those marked (R L) were found at Red lake only and the one marked (B and H) at Henning as well as at Bemidji. The adaptations of the plants of these formations are, of course, the same as those of the lichens of the *Cladonia* formations of rotten wood.

The following formation was distinctly discernible in the low woods about the tamarack swamps near Henning, the species composing it being unusually abundant. From the frequence of *Pertusarias* rare elsewhere in the region studied during the summer, I shall name it as follows:

PERTUSARIA LICHEN FORMATION OF TREES IN LOW WOODS (HENNING).

Physcia obscura (Ehrh.) Nyl.
Collema flaccidum Ach.
Collema nigrescens (Huds.) Ach.
Leptogium myochroum (Ehrh., Schaer.) Tuck.
Pertusaria velata (Turn.) Nyl.
Pertusaria pustulata (Ach.) Nyl.
Biatora glauconigrans Tuck.
Biatora rubella (Ehrh.) Rab.
Biatora varians (Ach.) Tuck.

I failed to find such a formation elsewhere in the territory explored. The plants in the formation grow on the common deciduous trees of the area, whereas at Bemidji and Red lake the swamps were surrounded for the most part by pines. As a whole the various adaptations of the plants are not difficult to detect. It is a little peculiar that the species of *Physcia*, belonging to this damp formation, belongs to the section of the genus having a well developed parenchymatous cortex rather than to the one having a non-cellular cortex of closely packed hyphæ. The *Collemas* with their non-cortical thallus and the *Leptogium* with a cortex of a single layer of cells are, of course, quite at home in such a damp habitat, as are the *Biatoras* with their thallus devoid of cortex. The *Pertusarias* have a fairly developed upper cortex.

The last formation to be recorded is a scattered one detected in shaded places at Bemidji, which may be designated as follows:

BIATORA LICHEN FORMATION OF MOSSES (BEMIDJI).

Pannaria languinosa (Ach.) Kbr.
Biatora vernalis (L). Fr.
Biatora sphæroides (Dicks.) Tuck.
Biatora hypnophila (Turn.) Tuck.

The first and last *Biatoras* are the common elements of the formation and may be found in this habitat commonly at Bemidji. The last *Biatora* is the only plant of the formation noticed elsewhere in such environment, nor were the other two *Biatoras* found elsewhere during the summer. The formation was observed in the Lake Superior region at Gunflint, where the second *Biatora* was wanting, and in the Snowbank lake area, where the first one did not occur. The plants of the formation all have rudimentary thalli devoid of cortical layers and are well adapted to the moist shaded habitat on the damp shaded sides of tree bases where they spread over the mosses.

Nearly all of the formations herein recorded are more or less *scattered* in the sense explained in the fifth paper of this series.* In this paper as in the others I have avoided attempting too close analysis as to amount of illumination, roughness of bark, amount of moisture, and have omitted from the lists of plants of the various formations those rarer lichens whose adaptations seemed most doubtful. Yet in attempting a detailed study of a single group of plants, I feel sure that, if I have erred at all, it has been in including some doubtful elements in a few of the formations. In general, I have found that one can attempt an amount of minute detail in such a study which could only be carried out by a long study of a single locality and which would probably not be more helpful than such general survey as I feel that I have been able to conduct in the field with some degree of success.

Notwithstanding the recording of 16 distinct formations for the region now under consideration and only 14 for southwestern Minnesota, I still adhere to the statement already recorded in this paper that the conditions of lichen growth are more uniform in the former area. The greater diversity in the latter territory may be seen in the fact that there is a larger amount of difference between similar formations in the various parts of the region, due to more variation in amount of moisture, shade, etc., and in the circumstance that some of the formations bearing different names in the former region are very much alike. On account of this greater uniformity of conditions under which similar formations seems to have developed, it has been even more difficult than in the preceding papers to ascertain why certain species are found in a formation at one place and not in the

* Fink, B. l. c., 307.

similar formation at another. I have, consequently, seldom attempted such explanations in this paper.

In the present paper, after a more extended study of lichen formations in the field, I have attempted a more minute discussion of structural adaptations based upon careful study of thalli in the laboratory. This analysis has not in most instances detracted from the apparent genuineness of the formations, though in some it has not been possible to show that every plant is structurally adapted to the formation in which it occurs.

Throughout this paper I have referred only once to the influence of physical structure and chemical composition of substrata as influencing the distribution of lichens and the composition of lichen formations. In the beginning, doubtless, lichen species were influenced in their choice of substrata by their adaptations to light, shade, moisture and other conditions, though of course such physical conditions of substrata as influence transfer of moisture are also to be considered as they have been in my discussicns, as have also roughness and smoothness of surface. No doubt both physiological and anatomical changes frequently result in lichens from adoption of certain substrata, but it is well known that the conditions of life in lichens are such that they are not so much dependent upon or influenced by their substrata as are most other plants. Thus a large proportion of lichens occur commonly upon substrata of the most varied chemical composition and physical structure, provided the conditions of light, moisture, etc., named above are favorable. Therefore these factors must, for the present at least, receive chief attention in the study of ecologic distribution of lichens, though the more difficult and less important subject of the influence of physical and chemical make up of substrata is well worth attention. Doubtless in the struggle of lichen species for possession of substrata, adaptations to chemical composition of substrata sometimes play an important part. For instances, the crustaceous lichens of the calcareous rocks and earth produce a fat which is probably utilized by the plants for purposes of nutrition. Hence, as these plants can build up the fats from material obtained wholly or in part from the calcareous substrata, they would have an advantage over lichens which can not thus utilize the carbon of the rocks, in the struggle for possession. Lichens produce other chemical compounds, some of which are doubtless dependent upon the nature of the substratum. To what extent these compounds are of use to the plant, or in what degree they are derived from the substratum is little known. Till these problems are solved we can hardly hope to discuss intelligently the influence of chemical composition upon distribution.

I am under obligations to Dr. A. Zahlbruckner, of Vienna, Austria, for aid in the determination of several of the species listed below, and also to Dr. E. Wainio, of Helsingfors, Finland, for examination and determination of the larger part of the *Cladonias*.

LIST OF SPECIES AND VARIETIES.

1. **Ramalina calicaris** (L.) FR. var. **fraxinea** FR.

On trees, infrequent. Battle lake, June 20, 1900, no. 39. Henning, June 28, 1900, no. 328 and July 2, 1900, no. 412. Thief River Falls, July 18, 1900, no. 796 and July 23, 1900, no. 869. Red lake, July 26, 1900, no. 882 and July 31, 1900, no. 1018.

2. **Ramalina calicaris** (L.) FR. var. **fastigiata** FR.

On trees, frequent. Battle lake, June 18, 1900, no. 2. Leaf hills, June 26, 1900, no. 209 and June 27, 1900, no. 246. Henning, June 28, 1900, no. 330 and 332 and July 2, 1900, no. 411. Bemidji, July 5, 1900, no. 471. Thief River Falls, July 17, 1900, no. 762. Red lake, July 26, 1900, no. 879 and July 31, 1900, no. 1006.

3. **Ramalina pusilla** (PREV.) TUCK.

On tamarack in swamps, rare. Henning, June 30, 1900, no. 370. Bemidji, July 7, 1900, no. 517 and July 8, 1900, no. 531. Red lake, July 31, 1900, no. 1012.

4. **Cetraria ciliaris** (ACH.) TUCK.

Common on pines and on tamaracks in swamps. Battle lake, June 20, 1900, no. 71. Henning, June 25, 1900, no. 188, June 28, 1900, nos. 315 and 323 and June 30, 1900, no. 378. Bemidji, July 4, 1900, no. 427, July 5, 1900, nos. 472, 476 and 490, July 7, 1900, nos. 522 and 526, July 12, 1900, no. 680 and July 14, 1900, no. 730. Red lake, July 28, 1900, no. 463, July 30, 1900, nos. 985 and 988, August 2, 1900, no. 1050 and August 3, 1900, no. 1070.

5. **Cetraria juniperina** (L.) ACH. var. **pinastri** ACH.

On pines and on tamaracks in swamps, rare. Bemidji, July

7, 1900, no. 516, July 9, 1900, no. 543 and July 12, 1900, no. 665. Red lake, July 27, 1900, no. 925 and August 4, 1900, no. 1083.

6. **Evernia prunastri** (L.) ACH.

Common on pines and abundant on tamaracks in swamps. Battle lake, June 23, 1900, no. 140. Henning, June 25, 1900, no. 187 and June 28, 1900, no. 312. Bemidji, July 4, no. 428, July 6, 1900, no. 518 and July 7, 1900, no. 531. Thief River Falls, July 19, 1900, no. 827. Red lake, July 28, 1900, no. 970.

7. **Usnea barbata** (L.) FR.

On trees, frequent. Henning, June 28, 1900, no. 513.

8. **Usnea barbata** (L.) FR. var. **florida** FR.

On trees, frequent. Battle lake, June 19, 1900, no. 27. Henning, June 25, 1900, no. 174. Leaf hills, June 27, 1900, no. 248. Bemidji, July 4, 1900, no. 425, July 7, 1900, no. 532 and July 12, 1900, no. 666. Thief River Falls, July 20, 1900, no. 838. Red lake, July 28, 1900, no. 945 and August 2, 1900, no. 1053.

9. **Usnea barbata** (L.) FR. var. **ceratina** SCHAER.

On trees, frequent. Henning, June 30, 1900, no. 375.

10. **Usnea barbata** (L.) FR. var. **dasypoga** FR.

On trees, abundant. Henning, June 25, 1900, no. 191.

11. **Usnea cavernosa** TUCK.

On trees, frequent. Henning, June 25, 1900, nos. 182, 192 and 193, June 28, 1900, nos. 298 and 337 and July 2, 1900, no. 410. Bemidji, July 5, 1900, nos. 469, 470 and 488, July 7, 1900, nos. 505, 513 and 519, July 8, 1900, nos. 534, 536 and 544, July 9, 1900, no. 546 and July 13, 1900, no. 715. Red lake, July 27, 1900, nos. 910, 912 and 920, July 28, 1900, no. 942 and July 30, 1900, nos. 978, 987 and 990.

11. **Alectoria jubata** (L.) TUCK.

On cedars, frequent. Bemidji, July 6, 1900, nos. 515 and 520 and July 13, 1900, no. 701.

13. **Alectoria jubata** (L.) TUCK. var. **chalybeiformis** ACH.

On pines and tamaracks, infrequent. Henning, June 28, 1900, no. 338. Bemidji, July 4, 1900, no. 426, July 5, 1900, no. 473, July 7, 1900, no. 512, July 8, 1900, no. 543 and July

12, 1900, no. 683. Red lake, July 28, 1900, no. 959 and July 30, 1900, no. 999.

14. **Theloschistes chrysophthalmus** (L.) NORM.

On trees, rare. Battle lake, June 18, 1900, no. 6. Bemidji, July 11, 1900, no. 619. Red lake, August 1, 1900, no. 1047.

15. **Theloschistes polycarpus** (EHRH.) TUCK.

On trees, frequent. Battle lake, June 19, 1900, no. 35 and June 20, 1900, no. 40. Leaf hills, June 26, 1900, no. 206. Bemidji, July 5, 1900, nos. 468 and 489, July 11, 1900, no. 653 and July 12, 1900, no. 675. Thief River Falls, July 18, 1900, no. 786. Red lake, July 27, 1900, no. 926.

16. **Theloschistes lychneus** (NYL.) TUCK.

On trees, abundant and rarely on rocks. Battle lake, June 19, 1900, no. 34. Bemidji, July 11, 1900, nos. 628 and 654. Thief River Falls, July 17, 1900, no. 773 and July 20, 1900, no. 842. Red lake, July 26, 1900, no. 884, July 28, 1900, no. 964 and August 1, 1900, no. 1045.

17. **Theloschistes concolor** (DICKS.) TUCK.

On trees, frequent. Battle lake, June 18, 1900, no. 16a. Leaf hills, June 27, 1900, no. 265. Thief River Falls, July 19, 1900, no. 826. Red lake, July 27, 1900, no. 930.

18. **Theloschistes concolor** (DICKS.) TUCK. var. **effusa** TUCK.

On trees, rare. Henning, June 25, 1900, no. 175. Bemidji, July 5, 1900, no. 460.

19. **Parmelia crinita** ACH.

On trees, rare. Bemidji, July 12, 1900, no. 691.

20. **Parmelia tiliacea** (HOFFM.) FLK.

In trees, infrequent. Battle lake, June 18, 1900, no. 16. Leaf hills, June 26, 1900, no. 208. Bemidji, July 4, 1900, no. 449. Red lake, July 31, 1900, no. 1003.

21. **Parmelia borreri** TURN.

On trees, frequent and rarely on rocks. Battle lake, June 20, 1900, no. 43 and June 21, 1900, no. 114. Leaf hills, June 27, 1900, nos. 281 and 286. Bemidji, July 11, 1900, nos. 647 and 658. Thief River Falls, July 19, 1900, no. 824. Red lake, July 26, 1900, nos. 891 and 893.

22. **Parmelia saxatilis** (L.) FR.

Common on trees and rare on rocks. Battle lake, June 21, 1900, no. 112. Henning, June 25, 1900, no. 190 and June 30, 1900, no. 379. Bemidji, July 4, 1900, no. 447, July 6, 1900, no. 514, July 7, 1900, no. 521, July 10, 1900, no. 583, July 11, 1900, nos. 646 and 660. Thief River Falls, July 19, 1900, no. 820 and July 23, 1900, no. 874. Red lake, July 26, 1900, no. 891a and August 1, 1900, no. 1038.

23. **Parmelia saxatilis** (L.) FR. var. **sulcata** NYL.

On trees and rocks, and more frequently on old logs, frequent. Battle lake, June 22, 1900, no. 134. Bemidji, July 4, 1900, no. 525 and July 7, 1900, no. 525. Thief River Falls, July 19, 1900, no. 813. Red lake, August 1, 1900, no. 1034 and August 2, 1900, no. 1049.

24. **Parmelia physodes** (L.) ACH.

On pines and tamarack, rare. Henning, June 28, 1900, no. 331. Bemidji, July 4, 1900, no. 429 and July 7, 1900, no. 514. Red lake, July 27, 1900, no. 913 and August 3, 1900, no. 1071.

25. **Parmelia olivacea** (L.) ACH.

On trees, frequent, and rarely on rocks. Battle lake, June 19, 1900, no. 31. Leaf hills, June 26, 1900, no. 243. Bemidji, July 4, 1900, nos. 443 and 446 and July 7, 1900, no. 513. Thief River Falls, July 20, 1900, no. 830. Red lake, July 26, 1900, no. 885, July 30, 1900, no. 991 and August 1, 1900, no. 1039.

26. **Parmelia olivacea** (L.) ACH. var. **aspidota** ACH.

On trees, common locally. Leaf hills, July 2, 1900, no. 385.

Not previously reported from Minnesota.

27. **Parmelia conspurcata** (SCHAER.) WAINIO.

On trees, locally common. Bemidji, July 12, 1900, nos. 672, 682 and 700.

Not previously reported from Minnesota.

28. **Parmelia caperata** (L.) ACH.

Common on trees and rare on rocks. Battle lake, June 19, 1900, no. 26. Henning, June 25, 1900, no. 195 and July 2, 1900, no. 409. Bemidji, July 7, 1900, no. 527 and July 11, 1900, no. 659. Thief River Falls, July 20, 1900, nos. 832, 833 and 841. Red lake, July 26, 1900, no. 898 and August 1, 1900, no. 1033.

29. **Parmelia conspersa** (EHRH.) ACH.

On granitic bowlders, rare. Bemidji, July 16, 1900, no. 745. Thief River Falls, July 10, 1900, no. 832a.

30. **Physcia speciosa** (WULF., ACH.) NYL.

On bowlders and trees, rare. Bemidji, July 11, 1900, nos. 598 and 613.

31. **Physcia hypoleuca** (MUHL.) TUCK.

On trees, rare. Bemidji, July 5, 1900, no. 484.

32. **Physcia granulifera** (ACH.) TUCK.

On trees, rare. Battle lake, June 21, 1900, no. 115.

33. **Physcia pulverulenta** (SCHREB.) NYL.

On trees and rocks, frequent. Battle lake, June 18, no. 9. Bemidji, July 9, 1900, no. 556 and July 11, 1900, nos. 618 and 657. Thief River Falls, July 17, 1900, no. 777, and July 18, 1900, no. 793. Red lake, July 26, 1900, no. 900, August 1, 1900, no. 1044 and August 2, 1900, no. 1051.

34. **Physcia stellaris** (L.) TUCK.

Abundant on trees and rare on rocks. Battle lake, June 19, 1900, no. 23 and June 20, 1900, no. 93. Leaf hills, June 26, 1900, no. 245. Bemidji, July 4, 1900, no. 445 and July 11, 1900, nos. 614 and 656. Thief River Falls, July 18, 1900, nos. 708 and 803 and July 29, 1900, nos. 836 and 859. Red lake, July 26, 1900, no. 886.

35. **Physcia stellaris** (L.) TUCK. var. **apiola** NYL.

On rocks, rare. Leaf hills, June 26, 1900, no. 212 and Red lake, August 1, 1900, no. 1029.

36. **Physcia astroidea** (FR.) NYL.

On rocks, once collected. Red lake, August 1, 1900, no. 1032.

Not previously reported from Minnesota.

37. **Physcia tribacia** (ACH.) TUCK.

On pines, rare. Bemidji, July 11, 1900, nos. 627 and 661. Red lake, July 27, 1900, no. 917.

38. **Physcia hispida** (SCHREB., FR.) TUCK.

On trees and rocks, rare. Henning, June 28, 1900, no. 335. Bemidji, July 11, 1900, nos. 632 and 655. Thief River Falls, July 18, 1900, nos. 781 and 791. Red lake, July 28, 1900, no. 972 and August 2, 1900, no. 1064.

39. **Physcia cæsia** (Hoffm.) Nyl.

On rocks, rare. Battle lake, June 23, 1900, no. 154. Leaf hills, June 26, 1900, nos. 203 and 239. Thief River Falls, July 18, 1900, no. 787. Red lake, August 4, 1900, no. 1078.

40. **Physcia obscura** (Ehrh.) Nyl.

On trees, common, and rarely on rocks. Battle lake, June 18, 1900, no. 4 and June 21, 1900, no. 121. Leaf hills, June 26, 1900, no. 211 and June 27, 1900, no. 270. Henning, June 29, 1900, no. 347 and June 30, 1900, no. 380. Bemidji, July 5, 1900, no. 461, July 11, 1900, no. 622 and July 12, 1900, no. 690. Thief River Falls, July 18, 1900, no. 782, July 19, 1900, no. 828 and July 28, 1900, no. 952. Red lake, Aug. 1, 1900, nos. 1027 and 1043 and Aug. 2, 1900, no. 1065.

41. **Physcia adglutinata** (Flk.) Nyl.

On trees, infrequent. Red Lake, Aug. 1, 1900, no. 1048.

42. **Sticta pulmonaria** (L.) Ach.

On cedars in swamp, rare. Bemidji, July 14, 1900, no. 727.

43. **Nephroma lævigatum** Ach.

On old cedars, in swamp, rare. Bemidji, July 14, 1900, no. 723.

44. **Peltigera horizontalis** (L.) Hoffm.

On earth in woods, rare. Bemidji, July 11, 1900, no. 645. Thief River Falls, July 17, 1900, no. 752.

Spores occasionally more than four-celled and frequently narrower than usual.

45. **Peltigera refuscens** (Neck.) Hoffm.

On earth, rare or infrequent. Battle lake, June 21, 1900, no. 118. Henning, June 30, 1900, no. 372. Thief River Falls, July 21, 1900, no. 862.

46. **Peltigera canina** (L.) Hoffm.

On earth, common. Battle lake, June 18, 1900, no. 14 and June 20, 1900, no. 81. Henning, June 25, 1900, no. 186. Leaf hills, June 26, 1900, no. 237. Thief River Falls, July 17, 1900, no. 751. Red lake, July 27, 1900, no. 933.

47. **Peltigera canina** (L.) Hoffm. var. **spuria** Ach.

On earth, frequent. Battle lake, June 20, 1900, no. 69. Leaf hills, June 26, 1900, no. 223. Bemidji, July 9, 1900, nos. 533 and 545. Thief River Falls, July 19, 1900, no. 809. Red lake, July 27, 1900, no. 909.

48. **Peltigera canina** (L.) HOFFM. var. **sorediata** SCHAER.

On earth, frequent. Battle lake, June 23, 1900, no. 152. Leaf hills, June 26, 1900, no. 216. Bemidji, July 4, 1900, no. 439. Thief River Falls, July 17, 1900, no. 765. Red lake, July 27, 1900, nos. 921 and 931.

49. **Peltigera canina** (L.) HOFFM. var. **leucorrhiza** FLK.

On earth in tamarack swamps, infrequent. Henning, June 25, 1900, no. 194 and June 29, 1900, no. 342. Bemidji, July 9, 1900, nos. 534 and 546. Red lake, July 28, 1900, no. 941.

Not previously reported from Minnesota.

50. **Heppia despreauxii** (MONT.) TUCK.

On calcareous earth, infrequent. Battle lake, June 20, 1900, no. 57. Leaf hills, June 26, 1900, no. 232, June 27, 1900, no. 264 and July 2, 1900, no. 394. Thief River Falls, July 17, 1900, no. 773.

51. **Pannaria languinosa** (ACH.) KBR.

On mossy tree bases, rare. Henning, June 28, 1900, no. 300. Bemidji, July 5, 1900, no. 458, July 9, 1900, no. 549 and July 11, 1900, no. 625. Thief River Falls, July 17, 1900, no. 763. Red lake, July 28, 1900, no. 946.

52. **Pannaria petersii** TUCK.

On calcareous pebbles, rare. Leaf hills, July 2, 1900, no. 399. With thallus nearly obsolete, the same condition occurring occasionally in northern Iowa.

Not previously reported from Minnesota.

53. **Collema pycnocarpum** NYL.

On trees, rare. Battle lake, June 19, 1900, no. 33 and June 21, 1900, no. 110. Bemidji, July 5, 1900, no. 467, July 11, 1900, no. 607, July 12, 1900, no. 686 and July 14, 1900, no. 724. Red lake, August 3, 1900, no. 1069.

54. **Collema flaccidum** ACH.

On trees, infrequent. Battle lake, June 23, 1900, no. 155. Henning, June 29, 1900, no. 351. Bemidji, July 12, 1900, no. 668.

55. **Collema nigrescens** (HUDS.) ACH.

On trees, frequent. Henning, June 29, 1900, nos. 349 and 359. Bemidji, July 12, 1900, no. 693. Red lake, August 3, 1900, no. 1074.

56. **Collema ryssoleum** Tuck.

On *Populus*, rare. Bemidji, July 12, 1900, no. 686.

Not previously reported from Minnesota.

57. **Collema pulposum** (Bernh.) Nyl.

On earth, rare. Battle lake, June 20, 1900, no. 77. Leaf hills, June 26, 1900, no. 207. Henning, June 29, 1900, no. 352. Leaf hills, July 2, 1900, no. 400. Bemidji, July 5, 1900, no. 477. Thief River Falls, July 17, 1900, nos. 769 and 770.

58. **Collema crispum** Borr.

On earth, frequent. Bemidji, July 11, 1900, no. 605.

59. **Collema limosum** Ach.

On earth, infrequent. Bemidji, July 10, 1900, no. 568, July 11, 1900, no. 637 and July 14, 1900, no. 736.

Not previously reported from Minnesota.

60. **Leptogium lacerum** (Sw.) Fr.

On earth, rare. Leaf hills, June 27, 1900, no. 287. Thief River Falls, July 18, 1900, no. 795.

61. **Leptogium myochroum** (Ehrh., Schaer.) Tuck.

On trees and rocks, rare. Battle lake, June 21, 1900, no. 123 and June 23, 1900, no. 156. Henning, June 30, 1900, nos. 381 and 382. Bemidji, July 5, 1900, no. 485 and July 13, 1900, no. 710.

62. **Placodium elegans** (Link.) DC.

On granite and limestone, rare. Battle lake, June 20, 1900, nos. 60 and 66. Bemidji, July 11, 1900, no. 638. Thief River Falls, July 17, 1900, no. 776.

63. **Placodium murorum** (Hoffm.) DC.

On lime bowlders, rare. Thief River Falls, July 9, 1900, no. 825. With deficient thallus.

64. **Placodium cinnabarrinum** (Ach.) Anz.

On granite rocks, infrequent. Battle lake, June 20, 1900, nos. 45 and 50. Leaf hills, June 27, 1900, nos. 276 and 282.

65. **Placodium aurantiacum** (Lightf.) Naeg. and Hepp.

On trees and granites, infrequent. Battle lake, June 19, 1900, no. 37. Leaf hills, June 27, 1900, no. 253. Bemidji, July 11, 1900, no. 643. Thief River Falls, July 19, 1900, no.

819 and July 21, 1900, no. 855. Some have very heavy thallus.

66. **Placodium cerinum** (HEDW.) NAEG. and HEPP.

On trees and granite rocks, frequent or infrequent. Battle lake, June 18, 1900, no. 13, June 19, 1900, no. 30, June 20, 1900, no. 73 and June 23, 1900, no. 164. Henning, June 25, 1900, nos. 177 and 199. Leaf hills, June 26, 1900, no. 244 and June 27, 1900, nos. 267 and 271. Henning, June 28, 1900, no. 321. Bemidji, July 4, 1900, no. 454, July 5, 1900, nos. 459 and 465 and July 11, 1900, no. 644. Thief River Falls, July 17, 1900, nos. 756 and 775, July 19, 1900, nos. 817, 818 and 823, July 20, 1900, no. 835 and July 21, 1900, no. 861. Red lake, July 26, 1900, no. 883, July 28, 1900, no. 953, July 30, 1900, no. 979, Aug. 1, 1900, no. 1025 and Aug. 2, 1900, no. 1061.

67. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **sidiritis** TUCK.

On granite rocks, infrequent. Battle lake, June 20, 1900, no. 68, and June 23, 1900, nos. 149 and 157. Leaf hills, June 27, 1900, nos. 247 and 263. Red lake, July 31, 1900, no. 1011.

68. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **pyracea** NYL.

On pine logs, frequent. Red lake, July 30, 1900, no. 983.

69. **Placodium ferrugineum** (HUDS.) HEPP.

On old pine, frequent. Bemidji, July 15, 1900, no. 705. Red lake, July 30, 1900, no. 976.

70. **Placodium vitellinum** (EHRH.) NAEG. and HEPP.

On old wood and granite rocks, rare. Battle lake, June 20, 1900, no. 104. Leaf hills, June 26, 1900, no. 240 and June 27, 1900, no. 278. Bemidji, July 10, 1900, no. 559. Red lake, July 28, 1900, no. 960 and July 30, 1900, no. 982.

71. **Placodium vitellinum** (EHRH.) NAEG. and HEPP. var. **aurellum** ACH.

On trees and granite rocks, infrequent. Battle lake, June 20, 1900, no. 56. Leaf hills, June 26, 1900, no. 251a and June 27, 1900, no. 257. Bemidji, July 11, 1900, no. 639.

72. **Lecanora rubina** (VILL.) ACH.

On granitic rocks, infrequent or rare. Battle lake, June 20, 1900, nos. 46, 49 and 51. Leaf hills, June 27, 1900, no. 284. Bemidji, July 11, 1900, no. 594.

73. **Lecanora muralis** (SCHREB.) SCHAER.

On rocks, rare. Red lake, August 1, 1900, no. 1030.

74. **Lecanora muralis** (SCHREB.) SCHAER. var. **saxicola** SCHAER.

On granitic rocks, locally frequent. Battle lake, June 20, 1900, no. 107. Leaf hills, June 26, 1900, no. 201.

75. **Lecanora muralis** (SCHREB.) SCHAER. var. **versicolor** FR.

On lime rocks, locally frequent. Battle lake, June 20, 1900, nos. 83, 97 and 102.

76. **Lecanora pallida** (SCHREB.) SCHAER.

On cedar in swamp, rare. Bemidji, July 13, 1900, no. 717.

77. **Lecanora subfusca** (L.) ACH.

On trees and rocks, common in last two localities only, Battle lake, June 20, 1900, nos. 54 and 75. Henning, June 25, 1900, no. 198. Leaf hills, June 27, 1900, no. 279. Bemidji, July 4, 1900, no. 457, July 5, 1900, nos. 471 and 499 and July 11, 1900, no. 606. Thief River Falls, July 20, 1900, no. 839. Red lake, August 3, 1900, no. 1075.

No. 54 is a peculiar form on rocks with scant thallus. No. 606 has border of exciple much raised.

78. **Lecanora subfusca** (L.) ACH. var. **argentata** ACH.

On pines, rare. Red lake, August 3, 1900, no. 1066.

79. **Lecanora subfusca** (L.) ACH. var. **coilocarpa** ACH.

On pine logs, rare. Red lake, July 30, 1900, no. 993.

80. **Lecanora variolascens** NYL.

On trees, common in Minnesota and Iowa, but usually sterile and hence not determinable. Battle lake, June 20, 1900, no. 76. Henning, June 29, 1900, no. 358. Thief River Falls, July 18, 1900, no. 800. Red lake, July 28, 1900, no. 975.

Not previously reported from Minnesota and new to North America.

81. **Lecanora hageni** ACH.

On rocks, rare. Battle lake, June 20, 1900, no. 109. Bemidji, July 11, 1900, no. 640.

82. **Lecanora varia** (EHRH.) NYL.

On trees, dead wood and rocks, infrequent. Battle lake, June 23, 1900, nos. 136 and 139. Henning, June 25, 1900, no. 184. Leaf hills, June 27, 1900, no. 252. Henning, June 28, 1900, nos. 309 and 333. Bemidji, July 5, 1900, nos. 492, 498 and 500 and July 12, 1900, nos. 695 and 697. Thief River Falls, July 17, 1900, no. 758 and July 18, 1900, nos. 784, 785 and 804. Red lake, July 27, 1900, no. 919 and August 1, 1900, no. 1022.

83. **Lecanora varia** (EHRH.) NYL. var. **polytropa** NYL.

On granitic rocks, rare. Battle lake, June 20, 1900, no. 84. Thief River Falls, July 21, 1900, no. 864. Red lake, July 27, 1900, no. 905.

Not previously reported from Minnesota.

84. **Lecanora varia** (EHRH.) NYL. var. **symmicta** ACH.

On dead wood, rare but widely distributed. Battle lake, June 23, 1900, nos. 138 and 142. Henning, June 28, 1900, no. 336. Bemidji, July 6, 1900, no. 545. Thief River Falls, July 18, 1900, no. 806 and July 21, 1900, no. 867. Red lake, July 28, 1900, nos. 954 and 966 and August 2, 1900, no. 1060.

85. **Lecanora varia** (EHRH.) NYL. var. **sæpincola** FR.

On old wood, rare. Battle lake, June 23, 1900, no. 150. Red lake, July 28, 1900, no. 957.

86. **Lecanora pallescens** (L.) SCHAER.

On trees in swamp, rare. Bemidji, July 13, 1900, no. 708.

87. **Lecanora verrucosa** (ACH.) LAUR. var. **mutabilis** TH. FR.

On trees, rare. Henning, June 29, 1900, no. 350. Bemidji, July 11, 1900, no. 609, July 13, 1900, no. 713 and July 14, 1900, no. 735. Red lake, August 3, 1900, no. 1067.

Not previously reported from Minnesota, but confused with *Pertusaria leioplaca* (Ach.) Schaer.

88. **Lecanora cinerea** (L.) SOMMERF.

On granitic bowlders, frequent. Battle lake, June 20, 1900, nos. 91, 99 and 101. Leaf hills, June 26, 1900, no. 233 and June 27, 1900, nos. 249, 260 and 295. Bemidji, July 10, 1900, no. 573, July 11, 1900, nos. 592 and 599 and July 14, 1900, no. 737.

89. **Lecanora calcarea** (L.) SOMMERF. var. **contorta** FR.

On bowlders, especially calcareous, rare. Battle lake, June 20, 1900, nos. 48, 92 and 100. Leaf hills, June 27, 1900, no. 296.

90. **Lecanora gibbosa** (ACH.) NYL. var **microspora** A. ZAHLB.

On exposed granitic bowlders, frequent. Leaf hills, July 2, 1900, no. 388.

Not previously reported from Minnesota and new to North America. Synonymy uncertain.

91. **Lecanora cervina** (PERS.) NYL.

On granitic bowlders, infrequent. Leaf hills, June 26, 1900, nos. 205 and 238, June 27, 1900, no. 251 and July 2, 1900, no. 397. Bemidji, July 16, 1900, no. 744.

92. **Lecanora fuscata** (SCHRAD.) TH. FR.

On granitic bowlders, infrequent. Battle lake, June 20, 1900, no. 80. Leaf hills, June 26, 1900, no. 218 and June 27, 1900, no. 280. Bemidji, July 10, 1900, no. 560. Red lake, July 27, 1900, no. 924.

93. **Lecanora privigna** (ACH.) NYL.

On bowlders, especially calcareous, rare. Leaf hills, June 27, 1900, nos. 259, 288 and 292 and July 2, 1900, no. 393. Bemidji, July 10, 1900, no. 584.

The last is a peculiar clustered form on granitic bowlders.

94. **Lecanora privigna** (ACH.) NYL. var. **pruinosa** AUCT.

On calcareous bowlders, rare. Leaf hills, July 2, 1900, no. 404.

95. **Lecanora xanthophana** NYL.

On granitic bowlders, locally frequent on high hills. Battle lake, June 20, 1900, no. 47 and June 23, 1900, no. 167.

96. **Rinodina oreina** (ACH.) MASS.

On granitic rocks, common in first locality. Battle lake, June 20, 1900, nos. 90 and 106. Leaf hills, June 26, 1900, no. 202. Thief River Falls, July 21, 1900, no. 865. Red lake, August 1, 1900, no. 1021.

97. **Rinodina sophodes** (ACH.) NYL.

On trees, old wood and rocks, common. Battle lake, June 18, 1900, no. 19, June 21, 1900, no. 119 and June 23, 1900, no. 162. Leaf hills, June 26, 1900, nos. 222 and 231. Henning, June 28, 1900, no. 339. Bemidji, July 5, 1900, nos. 464 and 478, July 7, 1900, no. 529 and July 11, 1900, no. 651. Thief River Falls, July 18, 1900, no. 808, July 19, 1900, no. 811 and July 21, 1900, no. 847. Red lake, July 26, no. 888 and July 28, 1900, nos. 935 and 969.

Spores commonly smaller than Tuckerman's measurements.

98. **Rinodina sophodes** (ACH.) NYL. var. **atrocinerea** NYL.

On tamarack in swamps, rare. Bemidji, July 6, 1900, nos. 538 and 547.

Not previously reported from Minnesota.

99. **Rinodina sophodes** (ACH.) NYL. var. **exigua** FR.

On granitic rocks, rare. Battle lake, June 23, 1900, no. 153. Leaf hills, June 26, 1900, no. 217.

100. **Rinodina bischoffi** (HEPP.) KBR.

On calcareous rocks, rare. Leaf hills, June 27, 1900, no. 291.

101. **Rinodina nigra** sp. nov.

On granitic rocks, infrequent. Battle lake, June 23, 1900, no. 146.

Thallus thin (12–22 mm.), indeterminate or subdeterminate, tartareous-areolate, ecorticate; the areoles densely crowded, angular, .5–1.25 mm. wide, dark slate color; upon a black hypothallus, which also borders the thallus more or less; algal cells globose, green (Cystococcus?), 8–14 mic. in diameter. Apothecia minute, .25–.50 mic. in diameter, immersed in the thallus, one, two or three in each areole; disk black, usually somewhat depressed, circular, with an entire thalline exciple, concolorous with the thallus; hymenium 75–90 mic. deep. Spores brown, 2-celled, oblong and frequently somewhat constricted at the septum, 9–15 mic. long and 5–8 mic. wide, 8 in asci. Paraphyses distinct, slender, unbranched, colorless throughout or brownish at tips. Asci 50–60 by 13–17 mic.

102. **Pertusaria multipuncta** (TURN.) NYL.

On trees, frequent. Bemidji, July 13, 1900, no. 711 and July 14, 1900, nos. 723, 725 and 726.

103. **Pertusaria communis** DC.

On trees in swamp, frequent. Bemidji, July 13, 1900, nos. 702 and 704.

104. **Pertusaria pustulata** (ACH.) NYL.

On trees, infrequent. Battle lake, June 22, 1900, no. 129. Henning, June 29, 1900, no. 361 and June 30, 1900, no. 383. Bemidji, July 13, 1900, nos. 707 and 719.

105. **Pertusaria finkii** A. ZAHLB. in litt.

On trees, rare or infrequent. Battle lake, June 20, 1900, no. 74, June 21, 1900, no. 113 and June 26, 1900, no. 128. Henning, June 30, 1900, no. 366. Bemidji, July 5, 1900, no. 480. Thief River Falls, July 18, 1900, no. 801. Red lake, July 31, 1900, nos. 1014 and 1019.

Thallus white or whitish, thin (0.2–0.28 mm.), determinate or subdeterminate, margin continuous, center unequal-verrucose and rimose, ecorticate, medullary hyphæ slender, algal cells globose, green, 10–15 mic. in diameter, disposed in more or less discrete clusters. Apothecia plentiful, clustered, immersed or finally becoming open-lecanoroid, about 0.75 mm. in diameter, irregular or subrotund, fuscescent or blackish, flat, rough; thalline margin persistent, thin, whitish, crenulate to sublacerate. Hymenium 320–370 mic. deep. Epithecium rufescent or fuscescent. Paraphyses slender, somewhat conglutinate. Asci elevate-saccate, containing 2 (rarely 1) spores, straight or somewhat curved, apex rounded and thickened, 170–190 mic. long and 42–46 mic. wide. Spores oval, ellipsoid or oblong, occasionally somewhat constricted along the sides, simple, colorless, 88–140 mic. long and 28–53 mic. wide, spore walls thick (9–12 mic.).

106. **Urceolaria scruposa** (L.) NYL.

On calcareous earth, rare. Battle lake, June 20, 1900, nos. 52 and 96. Leaf hills, June 27, 1900, no. 255.

107. **Stereocaulon paschale** (L.) FR.

On granitic bowlders, rare. Bemidji, July 10, 1900, no. 569 and July 16, 1900, no. 750. Red lake, August 4, 1900, nos. 1079 and 1082.

108. **Cladonia mitrula** TUCK.

On earth, rare. Battle lake, June 20, 1900, no. 53. Henning, June 28, 1900, no. 308. Leaf hills, July 2, 1900, no. 402.

109. **Cladonia botrytes** (HAG.) WILLD.

On coniferous stumps and logs, infrequent. Bemidji, July 4, 1900, no. 430 and July 6, 1900, no. 526. Thief River Falls, July 17, 1900, no. 771. Red lake, July 28, 1900, no. 974.

Not previously reported from Minnesota.

110. **Cladonia cariosa** (Ach.) Spreng.

On earth, infrequent. Leaf hills, June 26, 1900, nos. 226, 227 and 229. Bemidji, July 7, 1900, no. 503, July 10, 1900, nos. 565 and 566 and July 16, 1900, no. 741. Red lake, August 3, 1900, nos. 1075 and 1080.

111. **Cladonia pyxidata** (L.) Fr.

On earth and old logs, frequent. Henning, June 25, 1900, no. 180 and June 27, 1900, no. 255. Thief River Falls, July 17, 1900, no. 766. Red lake, July 27, 1900, no. 907.

112. **Cladonia pyxidata** (L.) Fr. var. **neglecta** (Flk.) Mass.

On old logs, frequent. Battle lake, June 18, 1900, no. 12. Thief River Falls, July 17, 1900, no. 757. Red lake, August 2, 1900, no. 1055.

Not previously reported from Minnesota.

113. **Cladonia pyxidata** (L.) Fr. var. **chlorophæa** Flk.

On old stumps, infrequent. Bemidji, July 6, 1900, no. 519.

Not previously reported from Minnesota.

114. **Cladonia fimbriata** (L.) Fr. var. **tubæformis** Fr.

On old wood, common. Battle lake, June 20, 1900, no. 78. Henning, June 25, 1900, no. 185 and June 28, 1900, no. 306. Bemidji, July 4, 1900, no. 438 and July 7, 1900, nos. 551 and 552.

115. **Cladonia fimbriata** (L.) Fr. var. **simplex** (Weis.) Flot.

On rotten wood, rare. Henning, July 2, 1900, no 407. Bemidji, July 6, 1900, no. 533. Apparently a synomym for above according to Wainio, but specimens very different.

Not previously reported from Minnesota.

116. **Cladonia fimbriata** (L.) Fr. var. **subulata** (L.) Wainio.

On earth in pine woods, infrequent. Bemidji, July 10, 1900, no. 574. Red lake, July 26, 1900, no. 902.

Not previously reported from Minnesota.

117. **Cladonia fimbriata** (L.) Fr. var. **fibula** Ach.

On earth usually under conifers, infrequent. Leaf hills, June 26, 1900, no. 230. Bemidji, July 5, 1900, nos. 462, 504 and 509, July 9, 1900, no. 535 and July 10, 1900, nos. 564, 571 and 585. Red lake, August 3, 1900, no. 1076.

Not previously reported from Minnesota.

118. **Cladonia fimbriata** (L.) FR. var. **apolepta** (ACH.) WAINIO.

On old wood, especially tamarack, frequent. Henning, June 28, 1900, no. 303. Bemidji, July 6, 1900, no. 521. Thief River Falls, July 19, 1900, no. 815.

Not previously reported from Minnesota and new to North America.

119. **Cladonia fimbriata** (L.) FLK. var. **ceratodes** (FLK.) WAINIO.

On earth under pines, common. Bemidji, July 6, 1900, no. 486. Red lake, July 28, 1900, no. 950.

Not previously reported from Minnesota and new to North America.

120. **Cladonia degenerans** FLK.

On earth under pines, rare. Bemidji, July 5, 1900, no. 510.

121. **Cladonia gracilis** (L.) NYL.

On earth and old wood, frequent. Battle lake, June 20, 1900, no. 79. Henning, June 28, 1900, nos. 311 and 319. Bemidji, July 4, 1900, no. 431. Red lake, July 30, 1900, no. 987.

122. **Cladonia gracilis** (L.) NYL. var. **verticellata** FR.

On earth and old wood, frequent. Battle lake, June 18, 1900, no. 11. Leaf hills, June 26, 1900, nos. 219, 220 and 221. Henning, June 28, 1900, no. 320. Bemidji, July 5, 1900, no. 572 and July 14, 1900, no. 732. Red lake, July 27, 1900, nos. 922 and 934a.

123. **Cladonia gracilis** (L.) NYL. var. **anthocephala** FLK.

On old logs, usually coniferous, frequent. Henning, June 28, 1900, no. 314. Bemidji, July 6, 1900, nos. 524 and 528 and July 10, 1900, no. 582. Thief River Falls, July 19, 1900, no. 797. Red lake, July 28, 1900, no. 968.

Not previously reported from Minnesota and new to North America.

124. **Cladonia gracilis** (L.) NYL. var. **hybrida** SCHAER.

On earth and old logs, common. Henning, June 28, 1900, nos. 302 and 304. Bemidji, July 4, 1900, no. 437, July 5, 1900, nos. 507 and 508 and July 6, 1900, nos. 515 and 550. Red lake, July 27, 1900, no. 934.

125. **Cladonia cenotea** (ACH.) SCHAER.

On earth, rare. Bemidji, July 9, 1900, nos. 534 and 536.

126. **Cladonia squamosa** HOFFM.

On old stumps in tamarack swamp, locally common. Bemidji, July 6, 1900, no. 516.

127. **Cladonia furcata** (HUDS.) FR.

On earth, rare. Bemidji, July 12, 1900, no. 684 and July 13, 1900, no. 720.

128. **Cladonia furcata** (HUDS.) FR. var. **scabriuscula** (DEL.) CEON.

On earth or old logs, rare. Henning, July 2, 1900, no. 416. Bemidji, July 13, 1900, no. 720.

Not previously reported from Minnesota and new to North America.

129. **Cladonia furcata** (HUDS.) FR. var. **paradoxa** WAINIO.

On earth or old wood under conifers, frequent. Henning, June 30, 1900, no. 371. Bemidji, July 4, 1900, no. 432, July 6, 1900, no. 522, July 10, 1900, nos. 562, 570, 567, and 586 and July 12, 1900, no. 677. Red lake, July 27, 1900, no. 906.

Not previously reported from Minnesota and new to North America.

130. **Cladonia rangiferina** (L.) HOFFM.

On earth and logs, common under pines in second locality. Henning, June 25, 1900, no. 181, June 28, 1900, no. 327 and June 29, 1900, no. 340. Bemidji, July 5, 1900, no. 505, July 7, 1900, no. 509, July 10, 1900, no. 587 and July 14, 1900, nos. 729 and 738. Thief River Falls, July 17, 1900, no. 761. Red lake, July 26, 1900, no. 903 and July 27, 1900, no. 923.

131. **Cladonia rangiferina** (L.) HOFFM. var. **sylvatica** (L.) RABENH.

On earth under conifers, common. Bemidji, July 5, 1900, nos. 503 and 511, July 6, 1900, no. 517 and July 14, 1900, no. 739. Red lake, July 27, 1900, nos. 908 and 915.

132. **Cladonia rangiferina** (L.) HOFFM. var. **alpestris** L.

On earth, infrequent. Bemidji, July 6, 1900, no. 517 and July 14, 1900, no. 739. Red lake, July 27, 1900, no. 915.

133. **Cladonia uncialis** (L.) FR.

On earth in pine woods, rare. Bemidji, July 9, 1900, no. 538.

134. **Cladonia deformis** (L.) HOFFM.

On old logs, rare. Bemidji, July 14, 1900, no. 734.

135. **Cladonia digitata** (L.) HOFFM.

On tamarack log in swamp, rare. Bemidji, July 6, 1900, no. 525.

136. **Cladonia bacillaris** NYL.

On old logs under pines, infrequent. Bemidji, July 4, 1900, no. 419 and July 9, 1900, nos. 540 and 541.

Not previously reported from Minnesota, but included under the next.

137. **Cladonia macilenta** (EHRH.) HOFFM.

On old logs, infrequent. Bemidji, July 9, 1900, no. 540. Red lake, July 28, 1900, no. 937.

138. **Cladonia cristatella** TUCK.

On old wood and earth, common. Battle lake, June 20, 1900, nos. 41 and 42. Leaf hills, June 26, 1900, no. 225. Henning, June 28, 1900, nos. 422 and 433, July 7, 1900, no. 435, July 8, 1900, no. 474, July 9, 1900, nos. 537 and 549 and July 10, 1900, no. 577. Thief River Falls, July 18, 1900, no. 778. Red lake, July 27, 1900, no. 904 and July 28, 1900, no. 956.

139. **Biatora decipiens** (EHRH.) FR.

On calcareous earth, frequent. Battle lake, June 20, 1900, no. 59. Leaf hills, June 27, 1900, no. 275 and July 2, 1900, no. 391.

140. **Biatora decipiens** (EHRH.) FR. var. **dealbata** TUCK.

On earth, infrequent. Leaf hills, June 27, 1900, no. 261 and July 2, 1900, no. 392.

141. **Biatora viridescens** (SCHRAD.) FR.

On tamarack logs in swamp, frequent. Bemidji, July 7, 1900, no. 528.

142. **Biatora vernalis** (L.) FR.

On mossy trees and on tamarack, infrequent. Bemidji, July 7, 1900, nos. 506, 508, 527 and 537 and July 13, 1900, no. 718.

143. **Biatora turgidula** (FR.) NYL.

On elms, rare. Bemidji, July 9, 1900, no. 553.

144. **Biatora leucophæa** (FLK.) TUCK.

On granite rocks, infrequent. Leaf hills, June 27, 1900, no. 277. Bemidji, July 11, 1900, no. 602. Thief River Falls, July 18, 1900, no. 792. Red lake, August 1, 1900, nos. 1031 and 1042.

145. **Biatora uliginosa** (SCHRAD.) FR.

On pine logs or earth under pines, infrequent. Bemidji, July 4, 1900, no. 440, July 5, 1900, no. 487 and July 9, 1900, nos. 539 and 542. Red lake, July 28, 1900, no. 971, July 30, 1900, nos. 977 and Aug. 1, 1900, no. 1046.

146. **Biatora myriocarpoides** (NYL.) TUCK.

On old pine and granite, infrequent. Bemidji, July 4, 1900, no. 424, July 10, 1900, no. 561 and July 16, 1900, nos. 743 and 749. Thief River Falls, July 20, 1900, no. 840, July 21, 1900, no. 851 and July 23, 1900, nos. 870 and 873. Red lake, July 28, 1900, nos. 959 and 967, July 30, 1900, no. 1002, Aug. 2, 1900, no 1058 and Aug. 4, 1900, no. 1077.

Part of the material here referred to has a colorless hypothecium and will doubtless be referred elsewhere after further study.

147. **Biatora varians** (ACH.) TUCK.

On trees, infrequent. Battle lake, June 18, 1900, no. 1 and June 23, 1900, no. 163. Leaf hills, June 26, 1900, no. 214. Henning, June 29, 1900, no. 356. Thief River Falls, July 21, 1900, no. 860.

148. **Biatora mixta** FR.

On poplars, frequent. Henning, June 29, 1900, no. 434. Bemidji, July 11, 1900, no. 629. Thief River Falls, July 21, 1900, no. 854. Red lake, Aug. 2, 1900, no. 1062.

Not previously reported from Minnesota.

149. **Biatora mixta** FR. var. **atlantica** TUCK.

On poplars, rare. Battle lake, June 20, 1900, no. 70.

Not previously reported from Minnesota and new to the interior of North America.

150. **Biatora atropurpurea** (MASS.) HEPP.

On poplars, infrequent. Bemidji, July 4, 1900, no. 455 and July 9, 1900, no. 551, Thief River Falls, July 21, 1900, nos. 777 and 846.

151. **Biatora prasina** FR. var. **byssacea** TH. FR.

On old logs in swamps, rare. Bemidji, July 7, 1900, no. 520.

Not previously reported from Minnesota.

152. **Biatora glauco-nigrans** Tuck.

On trees in low woods, infrequent. Henning, June 29, 1900, no. 355.

153. **Biatora sphæroides** (Dicks.) Tuck.

On mossy bases, rare. Bemidji, July 12, 1900, no. 663.

Not previously reported from Minnesota.

154. **Biatora hypnophila** (Turn.) Tuck.

On mossy earth, rare. Henning, June 29, 1900, no. 346 and June 30, 1900, no. 365. Bemidji, July 4, 1900, no. 452, July 5, 1900, no. 483, July 11, 1900, nos. 612 and 617 and July 14, 1900, no. 731. Thief River Falls, July 17, 1900, no. 768 and July 23, 1900, no. 871. Red lake, July 30, 1900, no. 998 and July 31, 1900, no. 1008.

155. **Biatora rubella** (Ehrh.) Rabenh.

On elms, ashes, poplars, infrequent. Battle lake, June 20, 1900, no. 72. Henning, June 25, 1900, nos. 171, 172 and 173. Bemidji, July 9, 1900, no. 554, July 11, 1900, no. 616, July 12, 1900, no. 681 and July 13, 1900, nos. 706 and 712. Thief River Falls, July 18, 1900, no. 783 and July 21, 1900, no. 868. Red lake, July 26, 1900, no. 892.

156. **Biatora fusco-rubella** (Hoffm.) Tuck.

On trees, infrequent. Henning, June 29, 1900, no. 345. Red lake, July 28, 1900, no. 936, July 31, 1900, no. 1015 and Aug. 1, 1900, no. 1041.

157. **Biatora suffusa** Fr.

On trees, rare. Red lake, July 27, 1900, no. 918.

158. **Biatora atrogrisea** (Delis.) Hepp.

On trees, infrequent. Henning, June 30, 1900, no. 376. Bemidji, July 11, 1900, no. 596. Thief River Falls, July 21, 1900, no. 858.

Not previously reported from Minnesota.

159. **Biatora inundata** Fr.

On pines and rocks, rare. Battle lake, June 20, 1900, nos. 65 and 103. Bemidji, July 10, 1900, no. 575. Red lake, July 30, 1900, nos. 981 and 984 and July 31, 1900, no. 1040.

160. **Biatora akompsa** Tuck.

On trees, common. Battle lake, June 18, 1900, no. 3.

Not previously reported from Minnesota and new to the interior of North America.

161. **Biatora muscorum** (Sw.) Tuck.

On earth, frequent. Battle lake, June 19, 1900, nos. 24 and 36 and June 20, 1900, no. 98. Leaf hills, June 27, 1900, no. 285.

162. **Lecidea enteroleuca** Fr.

On trees, common. Battle lake, June 18, 1900, no. 7, June 20, 1900, nos. 38 and 61, June 22, 1900, no. 130 and June 23, 1900, nos. 151 and 165. Leaf hills, June 27, 1900, nos. 250 and 274. Henning, June 29, 1900, no. 341 and June 30, 1900, nos. 363 and 369. Bemidji, July 4, 1900, no. 450, July 5, 1900, nos. 466 and 475, July 11, 1900, no. 633 and July 12, 1900, nos. 674 and 688. Thief River Falls, July 17, 1900, nos. 759, 764 and 774, July 19, 1900, no. 812 and July 20, 1900, no. 843. Red lake, July 27, 1900, nos. 928 and 932, July 28, 1900, no. 962, July 31, 1900, nos. 1004 and 1020 and August 1, 1900, no. 1026.

163. **Lecidea enteroleuca** Fr. var. **achrista** Sommerf.

On trees, infrequent. Battle lake, June 19, 1900, no. 25. Red lake, July 28, 1900, no. 973 and July 31, 1900, no. 1009.

164. **Lecidea enteroleuca** Fr. var. **flavida** Fr.

On tamarack stumps in swamps, rare. Bemidji, July 11, 1900, no. 610. Red lake, July 28, 1900, no. 949.

Not previously reported from Minnesota.

165. **Lecidea enteroleuca** Fr. var. **ambigua** Anz.

On old wood, rare. Battle lake, June 23, 1900, no. 143. Henning, June 25, 1900, no. 200. Bemidji, July 7, 1900, no. 518. Thief River Falls, July 18, 1900, no. 807.

Not previously reported from Minnesota.

166. **Lecidea acclinis** Flot.

On trees, infrequent. Battle lake, June 21, 1900, no. 120. Thief River Falls, July 19, 1900, no. 810 and July 21, 1900, no. 844.

167. **Lecidea** sp.

On dead tamaracks in swamp, rare. Henning, June 25, 1900, no. 178. Thallus grayish and evanescent, apothecia medium sized; hymenium pale; exciple and hypothecium brownish black; paraphyses distinct, colorless, filiform, brown-tipped; spores oblong, colorless, 4-celled, straight or slightly curved, 13–16 mic. long by 3½–5 mic. wide.

168. **Buellia alboatra** (HOFFM.) TH. FR.

On trees, rare. Battle lake, June 21, 1900, no. 117 and June 25, 1900, no. 158. Bemidji, July 11, 1900, nos. 679 and 687. Thief River Falls, July 23, 1900, no. 872. Red lake, July 27, 1900, no. 965.

169. **Buellia parasema** (ACH.) TH. FR.

On trees, infrequent. Leaf hills, June 27, 1900, no. 272. Bemidji, July 4, 1900, no. 434, July 7, 1900, nos. 510, 511 and 542 and July 12, 1900, nos. 662 and 696. Thief River Falls, July 20, 1900, no. 831. Red lake, July 28, 1900, no. 939, July 30, 1900, no. 939 and August 2, 1900, no. 1056.

170. **Buellia myriocarpa** (DC.) MUDD.

On pines, rare. Battle lake, June 19, 1900, no. 23. Bemidji, July 5, 1900, no. 488. Red lake, August 2, 1900, no. 1059.

171. **Buellia myriocarpa** (DC.) MUDD. var. **polyspora** WILLEY.

On cedar in swamps, rare. Bemidji, July 13, 1900, no. 714.

172. **Buellia pullata** TUCK.?

On granitic rocks, infrequent. Leaf hills, June 26, 1900, no. 241.

Spores 9–14 mic. long by 6–7.5 mic. wide, and thallus scanty.

173. **Buellia petræa** (FLOT., KBR.) TUCK.

On exposed granitic rocks, locally frequent. Battle lake, June 23, 1900, no. 158. Leaf hills, July 2, 1900, no. 386.

174. **Buellia petræa** (FLOT., KBR.) TUCK. var. **montagnæi** TUCK.

On exposed granitic rocks, locally common. Battle lake, June 20, 1900, no. 62 and June 23, 1900, no. 169. Leaf hills, June 27, 1900, nos. 283 and 294 and July 2, 1900, no. 396.

175. **Melaspilea arthonioides** (FEE) NYL.

On trees, rare. Battle lake, June 21, 1900, no. 122 and June 22, 1900, no. 133. Bemidji, July 11, 1900, no. 604. Thief River Falls, July 21, 1900, no. 849.

Not previonsly reported from Minnesota.

176. **Opegrapha varia** (PERS.) FR.

On trees, common. Battle lake, June 18, 1900, nos. 15 and 17 and June 19, 1900, nos. 29 and 32. Henning, June 25, 1900, no. 176 and June 30, 1900, no. 362. Bemidji, July 4, 1900, no.

448. Thief River Falls, July 18, 1900, nos. 779 and 790. Red lake, July 26, 1900, nos. 881 and 894 and August 1, 1900, no. 1040.

177. **Graphis scripta** (L.) ACH.

On trees, frequent, Battle lake, June 22, 1900, no. 124. Henning, June 24, 1900, no. 179. Bemidji, July 4, 1900, no. 453, July 11, 1900, nos. 603 and 648. Red lake, July 26, 1900, no. 880 and July 30, 1900, nos. 995 and 997.

178. **Graphis scripta** (L.) ACH. var. **limitata** ACH.

On trees, rare. Henning, June 30, 1900, no. 367. Bemidji, July 12, 1900, no. 667.

179. **Graphis scripta** (L.) ACH. var. **recta** (HUMB.) NYL.

On trees, rare. Bemidji, July 12, 1900, no. 664 and July 14, 1900, no. 728. Red lake, August 1, 1900, no. 1037.

180. **Arthonia lecideella** NYL.

On trees, infrequent. Battle lake, June 18, 1900, no. 5 and June 23, 1900, no. 161. Leaf hills, June 26, 1900, no. 242. Bemidji, July 4, 1900, no. 456, July 5, 1900, nos. 463 and 481 and July 9, 1900, no. 552. Thief River Falls, July 20, 1900, no. 837 and July 21, 1900, no. 856. Red lake, July 31, 1900, no. 1013.

181. **Arthonia patellulata** NYL.

On elms, rare. Bemidji, July 12, 1900, no. 699.

182. **Arthonia dispersa** (SCHRAD.) NYL.

On trees, probably common. Battle lake, June 20, 1900, nos. 44 and 67, June 22, 1900, no. 131 and June 23, 1900, no. 160. Henning, June 25, 1900, no. 183. Red lake, July 26, 1900, nos. 895 and 899, July 28, 1900, no. 958 and August 2, 1900, no. 1057.

183. **Arthonia** sp.

On trees, rare. Leaf hills, June 26, 1900, no. 213. Spores 4-celled in pyriform asci, 18–21 mic. long by 6–7 mic. wide. Apothecia differently disposed than in the next.

Not previously reported from Minnesota.

184. **Arthonia radiata** (PERS.) TH. FR.

On trees, rare. Battle lake, June 21, 1900, no. 116 and June 22, 1900, no. 135. Henning, June 29, 1900, no. 360. Red lake, July 26, 1900, no. 889 and July 31, 1900, nos. 1005 and 1017.

185. **Acolium tigillare** (Ach.) DN.

An old wood, rare. Battle lake, June 23, 1900, no. 137. Bemidji, July 5, 1900, no. 497 and July 6, 1900, no. 530.

186. **Calicium lucidum** (Th. Fr.) Fink.

On pines, tamaracks and dead wood, rare. Henning, July 2, 1900, no. 413. Bemidji, July 6, 1900, nos. 530 and 539 and July 11, 1900, no. 595. Red lake, July 30, 1900, no. 994 and August 3, 1900, no. 1072.

Not previously reported from Minnesota and new to North America.

187. **Calicium trichiale** Ach. var. **cinereum** Nyl.

On living and dead wood in swamps, rare. Henning, June 28, 1900, nos. 301 and 334. Bemidji, July 13, 1900, no. 709. Red lake, July 26, 1900, no. 901 and July 28, 1900, no. 938.

Not previously reported from Minnesota and new to the interior of North America.

188. **Calicium chrysocephalum** Ach.

On cedars in swamp, rare. Bemidji, July 6, 1900, nos. 507 and 535.

189. **Calicium trachelinum** Ach.

On old wood in tamarack swamp, locally common. Henning, June 28, 1900, no. 325 and July 2, 1900, no. 406.

Not previously reported from Minnesota.

190. **Calicium polyporæum** Nyl.

On *Polyporus versicolor*, rare. Bemidji, July 14, 1900, no. 736. Thief River Falls, July 19, 1900, no. 823. Red lake, July 28, 1900, no. 955.

Not previously reported from Minnesota.

191. **Calicium** sp.

On dead wood, especially in swamps, rare. Battle lake, June 23, 1900, no. 159. Henning, June 30, 1900, no. 374. Bemidji, July 7, 1900, no. 524 and July 12, 1900, no. 692.

Spores simple and compound. Referred to *C. quercinum* Pers. in no. IV. of this series of papers.

Not previously reported from Minnesota.

192. **Calicium curtum** Turn. and Borr. ?

On old stumps of conifers, especially in swamps, frequent. Henning, June 28, 1900, no. 317. Red lake, July 27, 1900, no. 911 and August 2, 1900, no. 1063.

Apothecia are large for the species and not pruinose at margin.

Not previously reported from Minnesota.

193. **Calicium trabinellum** (SCHAER.) KBR.

On old stumps of conifers, common at first locality. Henning, June 28, 1900, no. 310. Bemidji, July 11, 1900, no. 631.

Not previously reported from Minnesota and new to the interior of North America.

194. **Calicium parietinum** ACH.

On dead stumps of conifers, common especially in swamps. Henning, June 28, 1900, nos. 299 and 316. Bemidji, July 7, 1900, no. 523 and July 12, 1900, no. 678. Thief River Falls, July 21, 1900, no. 866. Red lake, July 27, 1900, no. 916 and August 1, 1900, no. 1035.

195. **Calicium pusillum** FLK.

On dead tamarack in swamps, rare. Henning, June 25, 1900, no. 196.

Not previously reported from Minnesota and new to North America.

196. **Calicium turbinatum** PERS.

On *Pertusaria communis*, rare. Bemidji, July 13, 1900, no. 703.

197. **Coniocybe pallida** (PERS.) FR.

On elms, infrequent. Henning, June 30, 1900, no. 368. Bemidji, July 11, 1900, no. 630 and July 13, no. 708. Thief River Falls, July 19, 1900, no. 716. Red lake, July 31, 1900, no. 1007.

198. **Endocarpon fluviatile** DC.

On rocks by water, infrequent. Red lake, August 2, 1900, no. 1052.

199. **Endocarpon hepaticum** ACH.

On earth, usually calcareous, abundant at second locality. Battle lake, June 20, 1900, no. 95. Leaf hills, June 27, 1900, nos. 256 and 273 and July 2, 1900, nos. 389 and 398. Bemidji, July 16, 1900, no. 742.

200. **Endocarpon pusillum** HEDW.

On calcareous pebbles, locally frequent. Leaf hills, June 27, 1900, no. 258 and July 2, 1900, no. 398.

201. **Staurothele umbrina** Wahl.)Tuck. var. **colpima**(Whnbl.), Nyl.

On granitic rocks in damp places and usually near water, locally common. Bemidji, July 11, 1900, nos. 593, 636, 641 and 642.

This plant was recorded in no. IV. of this series of papers and also in no. V. as *S. drummondii* Tuck. However, it agrees more nearly with European specimens of the present variety.

Not previously reported from Minnesota.

202. **Verrucaria nigrescens** Pers.

On rocks, frequent. Battle lake, June 20, 1900, nos. 86 and 87 and June 23, 1900, nos. 144 and 168. Leaf hills, July 2, 1900, nos. 387 and 403. Thief River Falls, July 17, 1900. no. 754. Red lake, July 27, 1900, no. 929 and July 28, 1900, no. 947.

203. **Verrucaria viridula** Ach.

On rocks along lake, common. Red lake, July 28, 1900, no. 943.

Not previously reported from Minnesota.

204. **Verrucaria muralis** Ach.

On rocks, especially calcareous, infrequent. Battle lake, June 23, 1900, no. 166. Leaf hills, June 27, 1900, nos. 289 and 293 and July 2, 1900, no. 404. Red lake, July 28, 1900, no. 940.

205. **Verrucaria fuscella** Fr.

On calcareous drift pebbles, frequent. Leaf hills, June 27, 1900, nos. 262 and 297.

A peculiar form.

206. **Verrucaria conoidea** Fr.

On lime pebbles, rare. Bemidji, July 11, 1900, no. 626.

Not previously reported from Minnesota and probably new to North America.

207. **Lagedia oxyspora** (Nyl.) Tuck.

On birch trees, probably abundant. Henning, June 25, 1900, no. 189. Bemidji, July 11, 1900, no. 608 and July 12, 1900, no. 671.

208. **Pyrenula punctiformis** (Ach.) Naeg.

On trees, rare. Battle lake, June 18, 1900, no. 18.

209. **Pyrenula punctiformis** (ACH.) NAEG. var. **fallax** NYL.

On birch trees, common. Henning, June 25, 1900, no. 170 and June 29, 1900, no. 353. Bemidji, July 11, 1900, nos. 601 and 624 and July 12, 1900, no. 670. Red lake, August 1, 1900, no. 1036.

The more I see of this plant, the more likely it seems that it will finally have to be separated entirely from this species.

210. **Pyrenula gemmata** (ACH.) NAEG.

On trees, rare. Thief River Falls, July 18, 1900, no. 798.

211. **Pyrenula hyalospora** (NYL.) TUCK.

On trees, locally frequent. Red lake, July 26, 1900, no. 887.

212. **Pyrenula cinerella** (FLOT.) TUCK.

On birch, locally common. Henning, June 29, 1900, no. 348.

213. **Pyrenula cinerella** (FLOT.) TUCK. var. **quadriloculata** FINK.

On birch, common. Bemidji, July 11, 1900, nos. 600 and 632. Red lake, July 26, 1900, no. 897.

214. **Pyrenula leucoplaca** (WAHL.) KBR.

On trees, especially poplars, common. Leaf hills, June 27, 1900, nos. 268 and 269. Henning, June 29, 1900, no. 344. Bemidji, July 9, 1900, no. 555, July 11, 1900, no. 611 and July 12, 1900, no. 676. Thief River Falls, July 17, 1900, no. 767, July 18, 1900, nos. 789 and 802 and July 19, 1900, no. 821. Red lake, July 28, 1900, no. 961.

215. **Pyrenula leucoplaca** (WAHL.) KBR. var. **pluriloculata** var. nov.

On trees, infrequent. Battle lake, June 18, 1900, no. 10 and June 21, 1900, no. 111. Henning, June 29, 1900, no. 357. Bemidji, July 11, 1900, no. 597. Thief River Falls, July 18, 1900, no. 799 and July 19, 1900, no. 829. Red lake, August 3, 1900, no. 1073.

Spores 5–8-celled.

XL. CORALLINÆ VERÆ OF PORT RENFREW.

K. Yendo, *Rigakushi*,

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I had the opportunity of studying seaweeds during the summer of 1901, at the Minnesota Seaside Station at Port Renfrew, Vancouver Island, B. C. The vicinity of the laboratory is extremely rich in marine life and afforded a good number of examples. I paid special attention to calcareous algæ, in which branch I have been deeply interested. Returning with the specimens to the Botanical Institute of the University of Tokyo, I carefully examined the Corallinæ (veræ) and prepared the present paper. Other specimens belonging to the subfamily Melobesiæ have been sent to Mr. M. Foslie, of Norway; his paper should also appear in a short time.

The material was partly dried and partly preserved in alcohol, the accompanying photographs being taken from the latter. The sections were made from alcoholic material by microtome, after decalcifying in Pereny's fluid. *Amphiroa tuberculosa* and a few other thick plants were not satisfactorily decalcified by the solution and the author found the following mixture specially suited for the purpose:

Hydrochloric acid, 5 per cent.........40 c.cm.
Alcohol, absolute.....................30 c.cm.
Chromic acid, 0.5 per cent...........30 c.cm.

The sections were stained after my usual method. One brings down the sections to pure water, and stains with Boemer's hæmatoxylin for 20–40 minutes; treat with acetic acid if necessary, and then dip in fuchsin (0.3 gr. in 100 c.cm. of 50 per cent. alcohol for one hour; 90 per cent. alcohol, abs. alcohol, xylol, balsam. The spores and spore-forming cells stain in red and the cell-walls of the vegetative cells in purple.

The author expresses his deepest thanks to Professor Conway MacMillan and Miss J. E. Tilden, who cared for him very kindly in every way during his stay at their private station; and to Professor J. Matsumura, of Tokyo, who offered many valuable suggestions on this work.

Synoptical Key of Corallinæ Enumerated in the Present Paper.

A. Conceptacles wart-like protuberances, on a surface of an articulus.
- o. Branches not pinnated.
  - a. Articuli cylindrical.....*Amphiroa cretacea* f. *tasmanica*.
  - b. Articuli of the upper and the middle portions cylindrical, subcompressed or compressed. *Amphiroa tuberculosa*.
  - c. Articuli of the upper and middle portions approximate, with depressed wings........*Cheilosporum californicum*.
- oo. Branches pinnated.
  - a. With short and thick stipes; upper articuli of the branches cordate or sagittate with round lobes; external margins of the ultimate articuli thick. *Cheilosporum frondescens*.
  - b. With long and thin stipes; upper articuli of the branches sagittate with acute lobes; external margins of the ultimate articuli thin...............*Cheilosporum planiusculum*.
  - c. With long and thick stipes; articuli of the axial branches hexagonal, without evident rib; conceptacles sometimes stalked............................*Cheilosporum MacMillani*

B. Conceptacles stalked, taking place of segments.
- o. Branches regularly pinnated, flabellate. *Corallina officinalis* var. *chilensis*.
- oo. Branches irregularly pinnated, several pinnules around the top of an articulus.
  - a. Pinnules not confusedly ramous. *Corallina vancouveriensis*.
  - b. Pinnules confusedly ramous and prickly. *Corallina aculeata*.

Habitat of Corallinæ at Port Renfrew.

The coast near the Minnesota Seaside Station chiefly consists of sandstone beds spreading horizontally. The beds are covered with water at high tide, and drained at low tide, leaving a good number of pools. The Corallinæ are mostly found between the tidal marks as well as in the pools. *Amphiroa tuberculosa* and *Amp. cretacea* f. *tasmanica* are found at the depth of 2–5 ft. below the low-water mark or the surface of the pools: the former species assumes very diverse forms when it is found at the margins of the pools, or between tidal marks. So also do *Corallina officinalis* var. *chilensis*, and *Cheilosporum MacMillani;* but the latter two are not infrequently found in more shallow water. *Cor. vancouveriensis* and its variety, on the contrary, are in most cases found at the margins of the pools, and in the region a little above the low-tide mark. They are also found epiphytic on the shells of Mya which cover the enormous area of the drained beds, thus making it easy to collect the entire bunch of the plants. *Cheil. frondescens* is also found in similar positions. *Cheil. planiusculum* is also an inhabitant of the pools, but slightly below the margins. When it grew above the water mark the frond is mostly stunted, apparently forming a granular mass. In the tide pools high above the water-level *Cor. aculeata* is generally found; water in such pools is mostly brackish, at least during the ebb tide hours; and the plant seemed to be able to adapt itself to it. This might be the probable cause why the ultimate articuli of the branches of this species are insufficiently calcified. Nevertheless, *Cor. vancouveriensis*, *Cheil. californicum*, *Cheil. planiusculum*, etc., may also be found in these brackish pools without any apparent modification in the characters of their fronds. Briefly speaking, *Cor. vancouveriensis* is an inhabitant of the shallowest water, and *Amp. tuberculosa*, as it were, of the deepest. The latter view may be corroborated by the fact that we often find the fragments of *Amp. tuberculosa* growing attached to the holdfast of *Nereocystis Lütkeana* hauled up out of water 20–50 feet deep.

Cor. pilulifera and its varieties which are abundantly found in Kamtchatka and in the northern part of Japan could not be found at Port Renfrew. Their places seem to be taken by *Cor. vancouveriensis* and *Cheil. planiusculum*. The habitat of these is much like that of the typical form of *Cor. officinalis* or *Cor. squamata*.

Cheil. frondescens which was described by Ruprecht* collected in Unalaska is common at this coast. Areschoug † re-

* Post. et Rupr.: Illustr. alg., p. 20.

† Aresch.: in J. Ag. Spec. alg., II., p. 549.

marked Ruprecht's plant to be probably a dwarfed form. This remark is true so far as my determination is correct; our plant is little larger than Ruprecht's f. *maxima mihi* being twice or more as large as his plant.

No specimens of *Jania* could be found. The water at Port Renfrew seems to be too cold to admit any member of this group. We are able to give only one datum here: the temperature of the water ½ ft. below the surface of a tidal pool, 10°.4 C.; 1 ft. below the surface of open sea 10°.2 C.; Atm. temp. 11°.55 C.

CORALLINÆ VERÆ OF PORT RENFREW.

1. **Amphiroa cretacea** Endl. f. **tasmanica** (Sond.). Pl. LI., Fig. 1.
= *Amphiroa tasmanica* Sond. in Plant Müll. (Linnæa, XXV.).
2d: in Müll. Frag. Phyt. Austr. Suppl.
Kützing: Tab. Phyc., VIII. Taf. 47, Fig. 11.

The plant found at Port Renfrew is identical with the Tasmanian form and not with *Amp. cretacea*, which was collected in Unalaska by Ruprecht. As has been already remarked by Kützing (*l. c.*, p. 23), *Amp. tasmanica* Sond. is quite similar to *Amp. cretacea* Endl. and it might better be reduced as above.

Not rare: 2–5 ft. below low-water mark, also in pools.

2. **Amphiroa tuberculosa** Endl. Pl. LI., Fig. 2; Pl. LVI., Figs. 1 and 2.
Aresch: in J. Ag. Spec. Alg., II., p. 538.
Harv: Ner. Bor. Am., p. 86.
= *Corallina tuberculosa* Post. et Rupr. Ill., p. 20, t. 40.
Kütz: spec. alg., p. 704.
? = *Amphiroa* (*Arthrocardia*) *epiphlegnoides* J. Ag. in Harvey's Notes on N. W. Am. Alg. (Journ. of Linn. Soc., VI., p. 169).
= *Amphiroa californica* in Prov. Museum at Victoria, B. C.

Judging by the figure delineated by Postels and Ruprecht (*l. c.*) our plant may be readily referred to the present species. It attains to 3–5 inches in its height with subdichotomous or lateral patent branches. The articuli are extremely variable in their form: those of the basal portion are invariably subcylindrical; those of the upper and the middle portions, cordate or sagittate, sometimes cylindrical or clavate; the cordate or sagittate articuli are more or less compressed and generally with subevident rib on the shaded surface: the terminal articuli are normally subcompressed obovate but sometimes globular or linear. The conceptacles are slightly bulged out, two to several, mostly immersed in the shaded side of a cordate articulus. Geniculi lineæform.

A branch is often simple with homogeneous cylindrical articuli. Plants with lots of this sort of branch are likely to be confounded with *Amp. cretacea* Endl. or the preceding forma. But the occurrence of the cordate articuli is the character upon which to separate the present species. *Amp. epiphlegnoides* seems to me quite similar to this plant. I mention it here as a synonym, however, with doubt, as I have not seen any authentic specimen of Agardh's plant.

Common: 2–5 ft. below low water mark, not seldom found, several fathoms deep.

3. **Cheilosporum californicum** (Dcne.). Pl. LIV., Fig. 2; Pl. LVI., Fig. 3.

Frond 3–5 cm. alta, stipitata, irregulariter di-trichotome ramosa: articulis stipitis cylindraceis diametro sesqui- 2- plo longioribus sursum latioribus et compressis; ramorum approximatis, adpressis mediis costatis, obreniformibus vel sagittatis lobis rotundis, longitudine inter genicula distantiam loborum 4-plo brevioribus; apicalium obovatis compressis: conceptaculis hemisphericalibus binis vel quatuor in utraque facie articuli instructis.

Amphiroa californica Dcne., Class f. d. Alg. et Cov., p. 112.
Kütz: Spec. Alg., p. 704.
Aresch: in J. Ag. Spec. Alg., II., p. 542.
Harv: Ner. Bor. Americ, p. 86.

As the original description of this plant was given somewhat briefly, a few other species have been mistakenly identified with it; and Areschoug counted it under the "species inquirendae" (*l. c.*). We have a specimen of *Amp. californica* Dcne., collected at Oregon and determined by Dr. Farlow. Our plant is exactly similar to this specimen and at once accords very well with Decaisne's description.

Not rare: low-water mark, also in tide pools.

4. **Cheilosporum frondescens** (Post. et Rupr.), f. **typica**. Pl. LII., Fig. 1; Pl. LVI., Figs. 4, 5 and 8.

Corallina frondescens Post. et Rupr., Ill. p. 20, t. XL., f. 103.

Arthrocardia ? frondescens (Post. et Rupr.) Aresch. in J. Ag. Spec. Alg., II., p. 549.

f. **maxima,** f. nov. Pl. LII., Fig. 3.

Fronde majore et crassiore; articulis pinnarum lobis latissimis saepe crenulatis, apicalium compressis obovatis vel spatulatis.

f. **intermedia,** f. nov. Pl. LII., Fig. 2.

Fronde tenuiore; articulis pinnarum compressis deltoideo-obcordatis lobis nonnunquam acutis.

f. **polymorpha,** f. nov. Pl. LII., Fig. 4; Pl. LVI., Figs. 6, 6a and 7.

Fronde minore; crassiuscula, polymorpha: tum articulis pinnarum obcordatis, obreniformibus vel sagittatis, apicalium obovatis vel globosis; tum articulis pinnarum axiumque cylindraceis, linearibus vel globosis.

Ruprecht's illustrations and description *l. c.* precisely coincide with f. *typica.* Areschoug remarked in J. Ag. Spec. Alg. *l. c.* that the original plant might have been a tiny form of the species. We have at Port Renfrew plants often attaining to several centimeters in height.

f. *typica* is a densely cæspitose plant, irregularly pinnated; the lowermost pinnæ attain to the length of the main stem, and thus give the appearance of trichotomy. The articuli are compactly arranged, the lower margin of an articulus in contact with the upper margin of the subsequent one. Conceptacles are mostly found two to four in number and placed on the shaded surface, often, however, solitarily immersed at the angles of a deltoid articulus.

f. *maxima* is distinguished from the other formæ by its large and compressed articuli at the upper portion of the branches. These articuli measure 2–5 mm. broad, 1.5–2 mm. long and are often cleft at their lobes. The branches are not so dense as in f. *typica.*

f. *intermedia* is characterized by having the upper portions of the fronds revoluted downwards while it is yet young. The articuli are rather less wide than those of f. *typica* and in every part thin. The lobes of the articuli are angled and consequently more loosely arranged.

f. *polymorpha* attains to a length of scarcely one inch and has its articuli thick and rough. Its form is very variable, sometimes assuming quite an aberrant appearance (Pl. LVI., Fig. 6, 6a) so that we could not suppose it to belong to this species, had it not been provided with some normal branches in a portion of the frond (Pl. LII., Fig. 4).

Although I distinguish these four formæ, intermediate forms between them are naturally met with. Especially f. *intermedia* and f. *polymorpha* are likely to be confounded with the abnormal forms of *Cheil. planiusculum*. In this case the external thick margin of the apical articuli and the robust stipes are the important characters of this species to separate it from the latter. The apical articuli of *Cheil. planiusculum* are mostly thin and compressed, and the stipes are delicate filiform. Nevertheless, it would not be an unreasonable supposition that the hybrid between *Cheil. frondescens* and *Cheil. planiusculum* may occur in nature.

Common: between tide marks, also in pools.

5. **Cheilosporum planiusculum** (Kütz.). Pl. LIII., Figs. 1–3; Pl. LVI., Figs. 9 and 10.

Fronde dense cæspitosa suberecta, 3–7 cm. alta, superne complanata, bi-tripinnata; articulis axium inferioribus tenuioribus cylindraceis mediis superioribusque compressis late triangularibus subcostatis, pinnarum sagittatis lobis acutis sæpe cordatis, pinnularum ancipitibus lanceolatis vel linearibus, ultimis obovatis compressis; geniculus brevissimis; conceptaculis hemisphæricalibus, 2–5 in articulo instructio.

Corallina planiuscula Kütz., Tab. Phyc., VIII., p. 31, taf. 63, Fig. 3.

The present plant is extremely variable in the shape of its articuli, and sharp definition is hard to give. Kützing counted four formæ in the original description (*l. c.*) though I could not find any form referable to *f. laciniata*. The other three formæ may be found mixed together in one bunch of the plant, often branches of different forms occurring in one individual. In an extreme instance, especially in a plant growing at high-tide mark, the frond becomes a moniliform filament with a few articuli of the normal shape (Plate LII., Fig. 3). Generally speaking, the articuli of the upper and middle portions are sagittate, with lobes thin, delicate and sharp at the upper angles, and with evident ribs at the middle; the pinnules are thin, spatulate or lanceolate. As the consequence, an articulus is not approximate with its adjacent ones as in *Cheil. frondescens* f. *typica* (comp. Pl. LVI., Fig. 4, and Pl. LVI., Fig. 10).

The delicate moniliform stipes, and the thin external margin of the apical articuli are the important characters of this species to distinguish it from the preceding species.

Comparatively common; low tide mark, also in pools.

6. **Cheilosporum MacMillani** sp. nov. Plate LII., Figs. 4 and 5; Pl. LVI., Figs. 11–14.

Fronde crassa nudusculo-stipitata, 4–10 cm. alta, inferne subteretibus superne flabellata bi-tripinnata; pinnis pinnulisque creberrimis erecto-patentibus sursum sensim brevioribus: articulis stipitum cylindraceis diametrum subæquantibus, mediis et superioribus compressis medio ventro elevatis, hexagonis vel cuneato-deltoideis diametro sesquibrevioribus, pinnarum ancipitibus lineari-sagittatis vel lanceolatis, ultimio ellipsoideis sæpe incrassatis; conceptaculis verrucæformibus in utraque facie instructis vel subcompressis in apicibus pinnularum immersis, nonnunquam pyriformibus pedunculatis.

This plant has its articuli of the upper part of the main branches more highly elevated on the ventral side than on the dorsal. The articuli of the lower portion are thick and moniliform, gently compressed upwards: in the upper and middle portion they become hexagonal or truncated, shorter than the breadth.

According to the description* of *Amphiroa wardii* Harv. and *Amp. mallardiæ* Harv., the present species has some common characters with them so that I hesitated for a time to name it as a new species. But the attachment of the conceptacles of our plant is rather peculiar, only one similar example being hitherto known in *Cheil. maximum.*† The eramiferous articuli of the pinnæ of ours are lineari-sagittate with lobes projected upwards; and the articuli of the upper portions of the main branches are hexagonal, much broader than the height. These various characters may easily distinguish ours from Harvey's plants. Not common; low-tide mark.

7. **Corallina officinalis** var. **chilensis** Kütz. Pl. LIV., Fig. 1; Pl. LVI., Fig. 15.

Fronde erecta, 5–10 cm. alta, inferne teretiuscula, superne flabellata bi-tripinnata: articulis inferioribus compressiusculis,

* Harvey: Nereis Austr., p. 99.

† Yendo: Cor. verae Japan. (Journ. of Sci. Coll. Tokyo, vol. XVI., art. III.)

mediis superioribusque oblongo-cuneatis compressis, pinnarum sterilium linearibus vel lanceolatis ancipitibus, ultimis compressis obovatis; conceptaculio pedunculatis subcompressis sæpe corniculatis. Color rubro-violaceus.

Corallina officinalis chilensis Kütz., Tab. phyc., VIII., p. 32, *taf. 66, Fig. 1.*

Cor. officinalis L. f. δ Yendo. Cor. veræ Japan., Pl. VII., Fig. 13 (Journ. Sc. Coll. Tokyo, Vol. XVI.).

The sterile specimens of this variety have been collected at Hakodate, a port in the northern part of Japan. As they lacked the conceptacle I was not able to satisfactorily determine the species and included them under the *Cor. officinalis* L. The specimens collected at Port Renfrew are fortunately fertile and accord very well with the description and figures of Kützing's Tab. Phyc. and at the same time correspond with the Hakodate specimens.

As I before noted (*l. c.*), this plant is a somewhat variable form to be counted under the species *Cor. officinalis* L.

Not very common; low-water mark, also in pools at the depth of 2–3 ft. below the surface.

8. **Corallina vancouveriensis** sp. nov. Pl. LIV., Fig. 3; Pl. LV., Figs. 1 and 2; Pl. LVI., Figs. 16–17.

Fronde 5–15 cm. alta, multicipite, longe stipitata, ramis bi-tri-pinnatis, sæpe pinnulis ex apice articuli egredientibus; articulis infinis globosis, mediis superioribusque subclavatis diametro æqualibus vel 2-plo longioribus tereti-compressis, ultimis obovatis subcompressis; articulis pinnarum cylindraceis linearibus vel alato-projectis digitatis; conceptaculis globosis vel pyriformibus stipitatis, sæpe corniculatis.

f. **typica,** f. nov. (Pl. LIV., Fig. 3; Pl. LVI., Fig. 16.)

Fronde plena articulorum linearum vel alato-projectorum digitatorum, conceptaculis globosis longe stipitatis.

f. **densa,** f. nov. (Pl. LV., Fig. 1; Pl. LVI., Fig. 17.)

Fronde dense ramosa, conceptaculis pyriformibus pedunculatis.

Both formæ approach one another and a sharp boundary is hard to draw. But f. *typica* is thicker and larger than the other and has abundance of linear or lanceolate long pinnæ in the upper part of the frond. The high tide form of this species assumes a diverse appearance; its stipes are thick and stunted, the pinnules in the upper portion are robust and fan-shaped, generally crenulated at the external margin.

Most common between tide marks on the margins of the pools.

9. **Corallina aculeata** sp. nov. Pl. LV., Fig. 3; Pl. LVI., Figs. 18–19.

Fronde 5–10 cm. alta, stipitata, irregulariter bi-tripinnata, sæpe pinnulis ex apice articuli egredientibus; articulis inferioribus diametro sesquilongioribus, pinnarum pinnularumque fragilissimis digitato-laciniatis aculeatio, sæpe cylindraceis vel linearibus; conceptaculis subcompressis cornibus aculeatis.

The pinnules of this plant are characteristic: they are brittle, delicate and confusedly branched. The ultimate articuli of the main branches as well as some of the young pinnules are always weakly calcified; and the apices of these articuli are liable to shrink in the exsiccation. In other respects it is closely allied to *Cor. vancouveriensis* f. *typica*, so that it might be taken as a local form caused by the mode of habit. Indeed a young and sterile frond of this species is hardly separable from it, if the apical articuli were not weakly calcified.

Common; high-tide pools.

Explanation of Plates.

The figures in Plates LI.–LV. are all in natural size, taken from the alcoholic specimens.

Plate LI.

1. *Amphiroa cretacea* Endl. var. *tasmanica* Sond.
2. *Amphiroa tuberculosa* Endl.

Plate LII.

1. *Cheilosporum frondescens* (Post. et Rupr.) f. *typica*.
2. do. f. *intermedia*.
3. do. f. *maxima*.
4. do. f. *polymorpha*.

Plate LIII.

1. *Cheilosporum planiusculum* (Kütz.) f. *regularis*.
2. do. f. *normalis*.
3. An abnormal form of the same species found at high-tide mark. The fronds are filamentous with moniliform articuli; a few sagittate articuli are to be found in some parts.

4 and 5. *Cheilosporum MacMillani.* In figure 4 wart-like conceptacles as well as pyriform ones are to be found on the same branch.

PLATE LIV.

1. *Corallina officinalis* L. var. *chilensis* Kütz
2. *Cheilosporum californicum* (Dcne.).
3. *Corallina vancouveriensis* f. *typica.*

PLATE LV.

1. *Corallina vancouveriensis* f. *densa.*
2. A high-tide form of *Corallina vancouveriensis.*
3. *Corallina aculeata.*

PLATE LVI.

Figures 1 and 2. *Amphiroa tuberculosa* Endl.

1. Diagrammatic figure of the longitudinal section of an articulus showing four conceptacles, three of which are cut in meridional direction, the remaining one in crosswise. × ca. 15.

2. A conceptacle cut in meridional direction showing the tetrasporangia. Zeiss 2 × BB.

Figure 3. *Cheilosporum californicum* (Dcne.).

A portion of branch showing the conceptacles. The scars of broken conceptacles are seen as deep excavations. × ca. 3.

Figures 4–8. *Cheilosporum frondescens* (Post. et Rupr.).

4. f. *typica;* a portion of frond. × ca. 4.

5. " a fertile branch. × ca. 5.

6 and 6*a*. f. *polymorpha;* portion of frond. × ca. 3½.

7. " a fertile branch. × ca. 4.

8. Cross section of a fertile articulus of f. *typica.* The dotted line indicates the boundary between the cortical part and the medullary.

Figures 9–10. *Cheilosporum planiusculum* (Kütz.).

9. f. *normalis.* × ca. 5.

10. f. *regularis.* × ca. 5.

Figures 11–14. *Cheilosporum MacMillani.*

11–12. Portions of the fertile branches showing pyriform conceptacles taking places of the pinnules (11), or one or more immersed in the pinnules (12). × ca. 2.

13. Portions of a fertile branch, showing wart-like conceptacles, one of them are found inserted at the apex of a pinnule. × ca. 2.

14. Meridional section of a pyriform conceptacle, showing an antheridium: the granular mass in the cavity is an aggregation of spermatozoids. Zeiss 2 × BB.

Figure 15. *Corallina officinalis* L. var *chilensis* (Kütz.). Meridional section of a conceptacle, showing the tetrasporangia. Zeiss 2 × BB.

Figures 16–17. *Corallina vancouveriensis.*

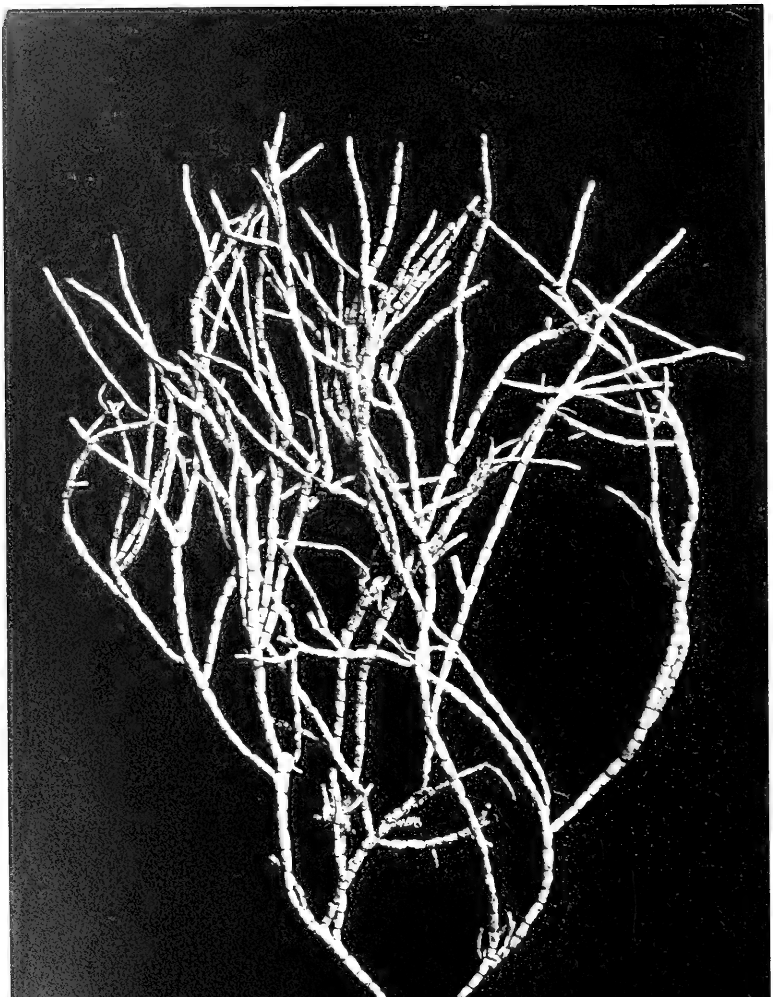
16. f. *typica.*

17. f. *densa.*

Figures 18–19. *Corallina aculeata.*

18. A portion of frond. × ca. 4.

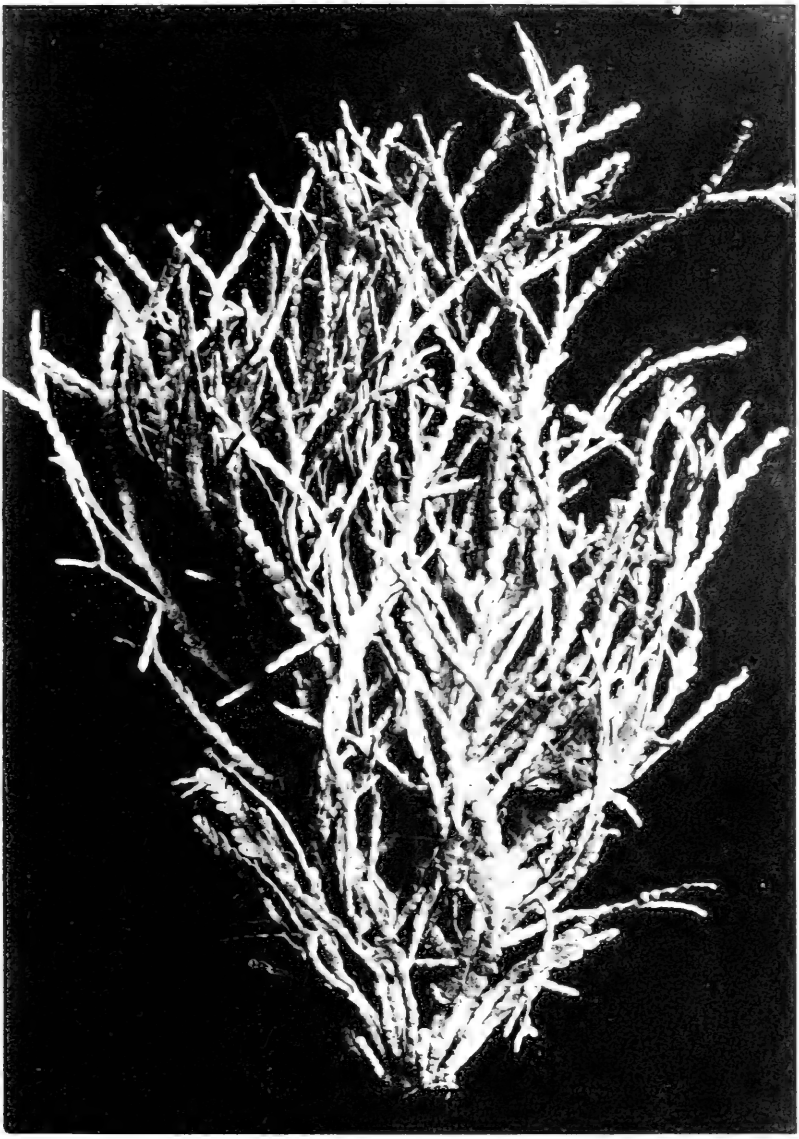
19. A young frond found in a brackish pool high above the tidal mark.



R. ... ET K. YENDO. PHOTO.

1

PLA



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HELIOTYPE CO., BOSTON.

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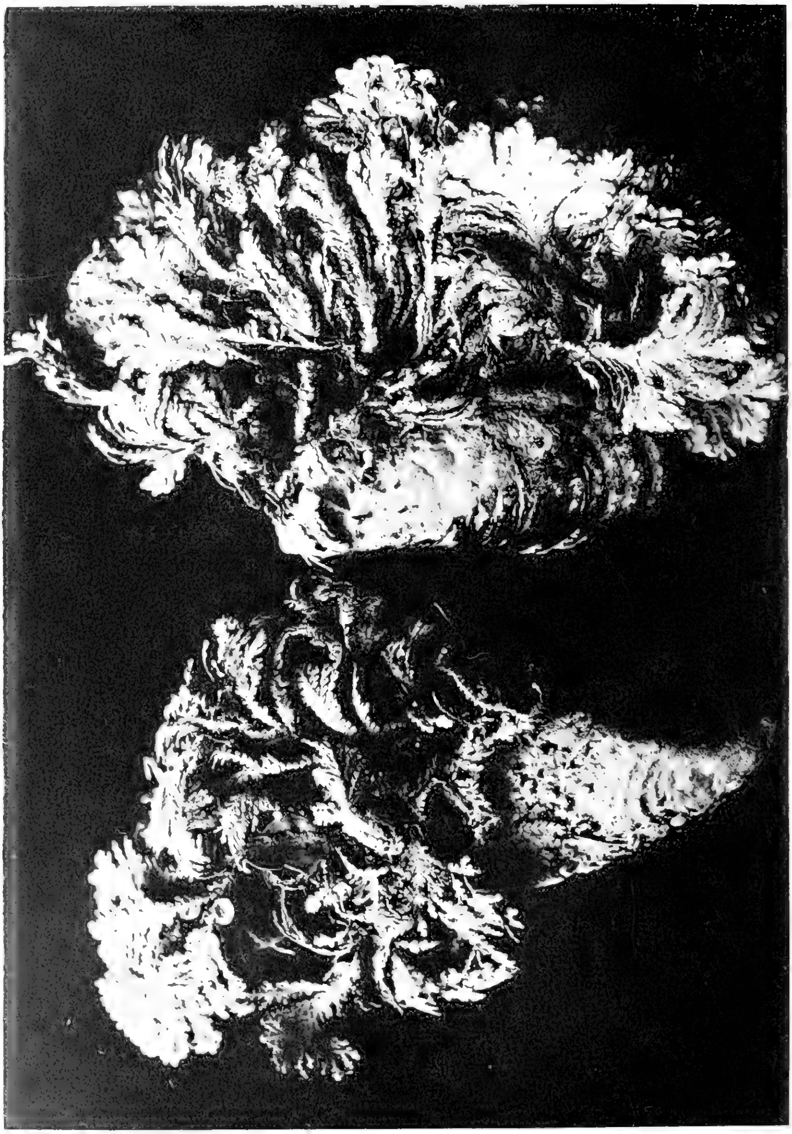
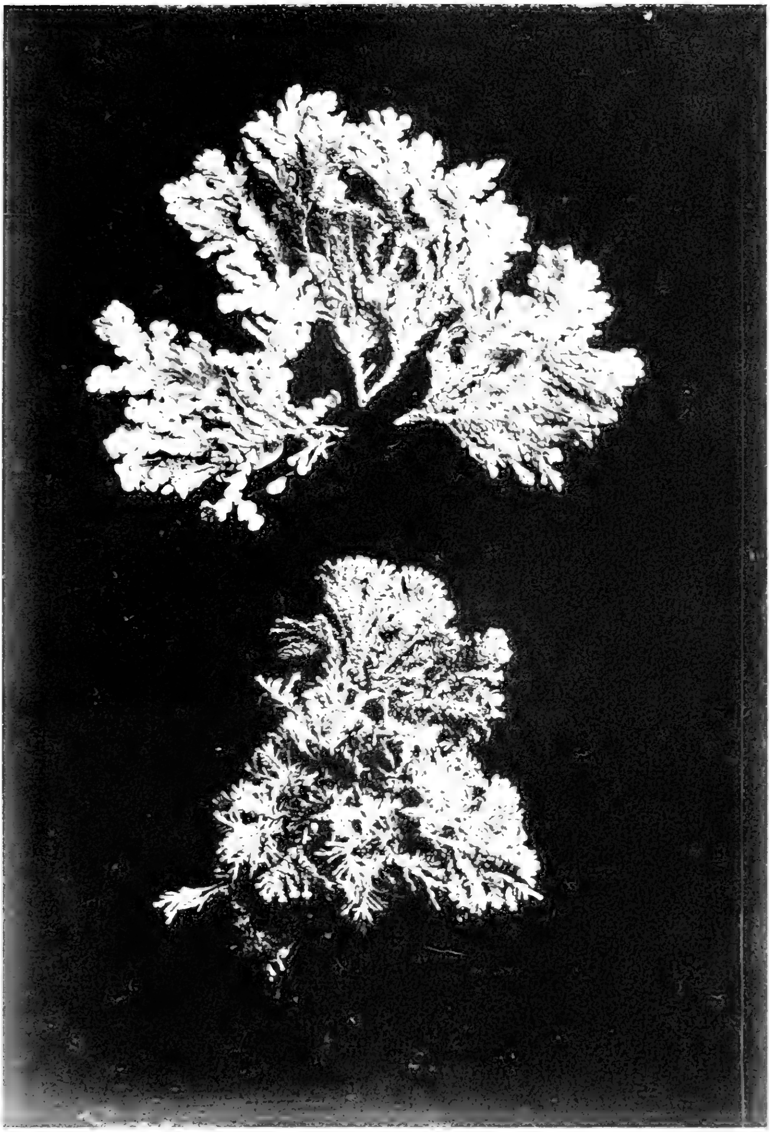
2



R. UCHIYAMA ET K. YENDO. PHOTO.



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4

HELIOTYPE CO., BOSTON.

II.

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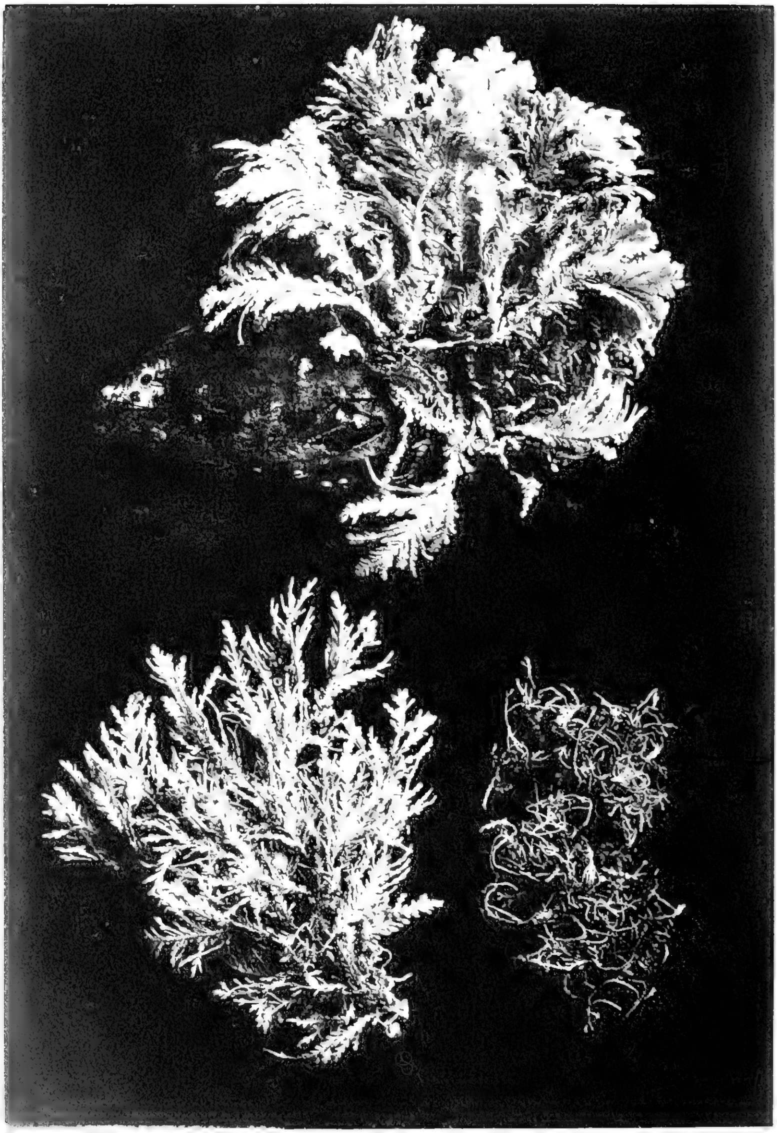

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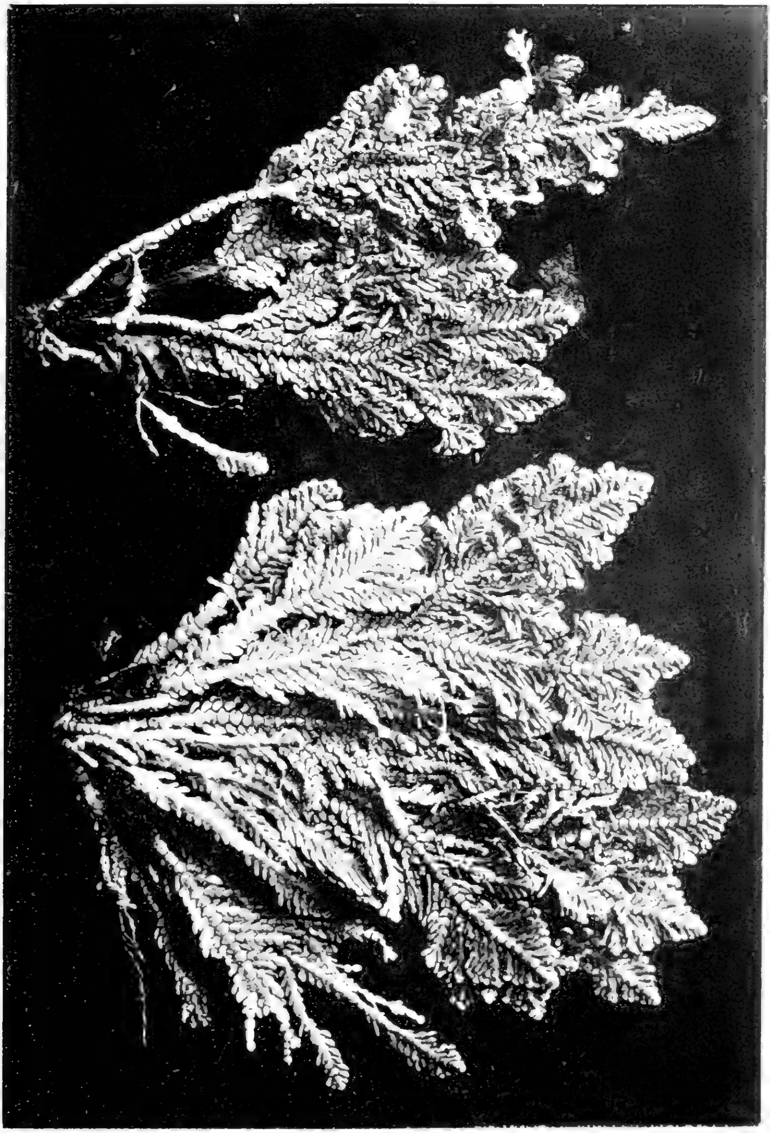
3

R. UCHIYAMA ET K. YENDO. PHOTO.

PL.



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R. UCHIYAMA ET K. YENDO. PHOTO.

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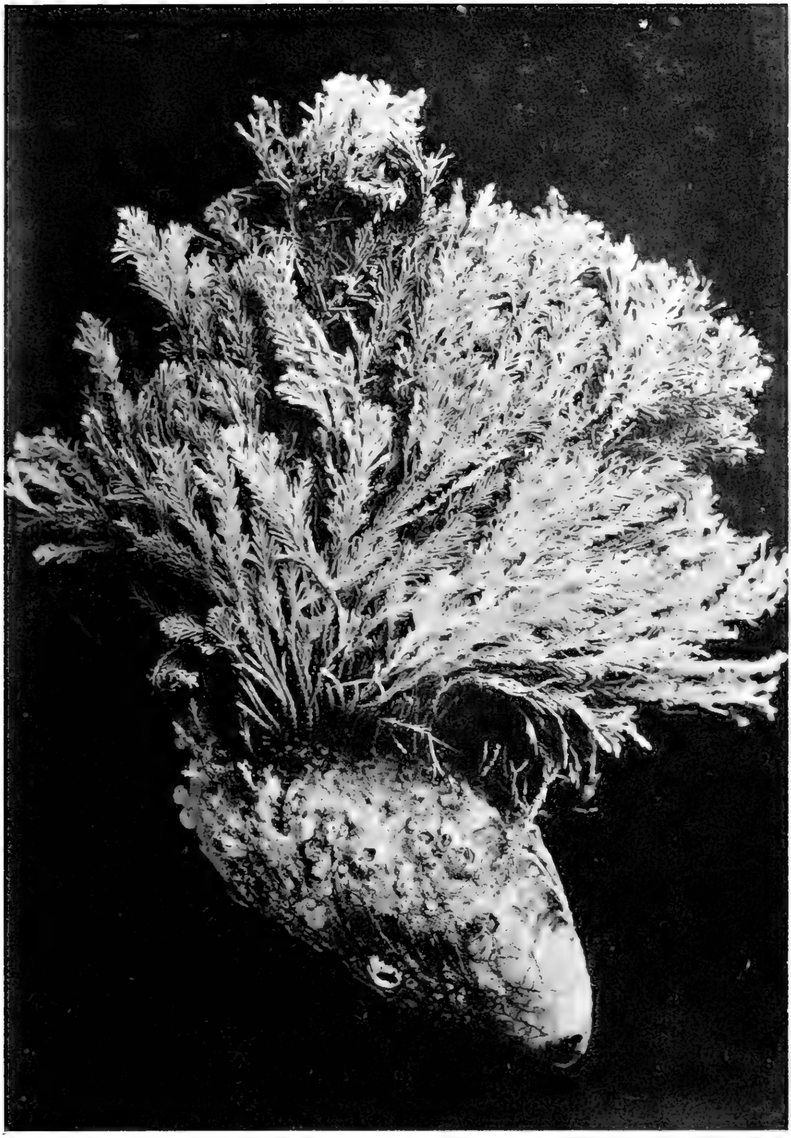

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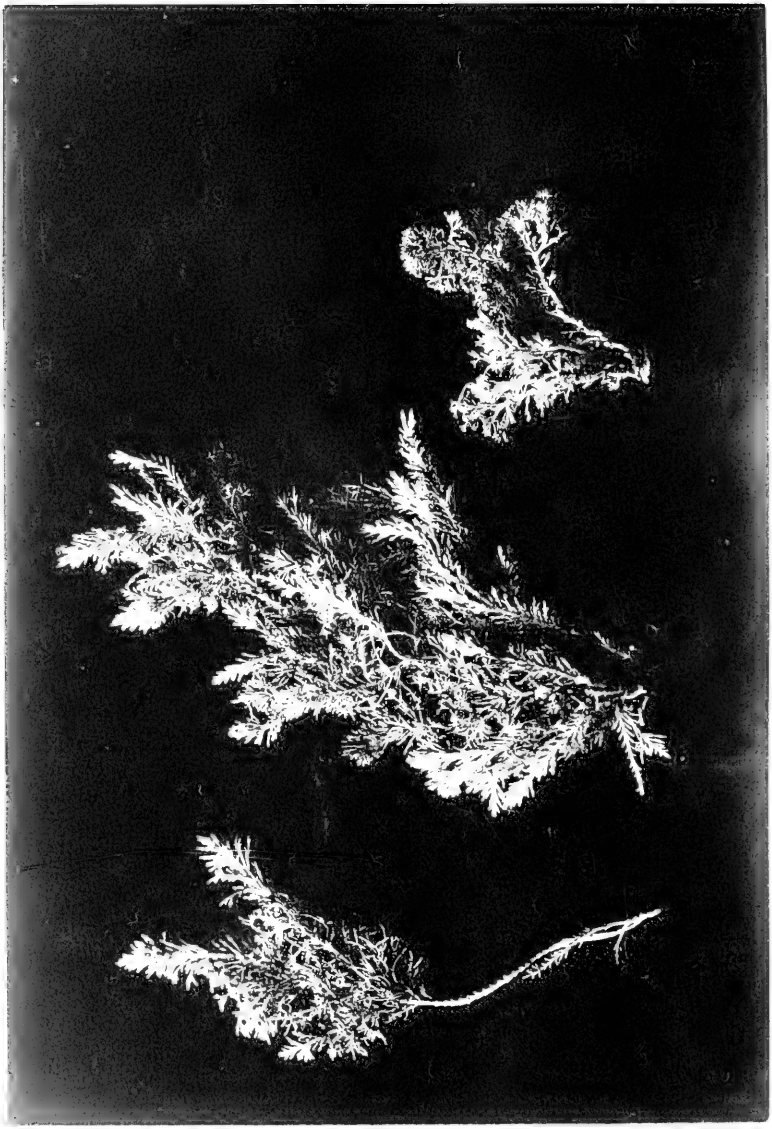

R. Uchiyama et K. Yendo. Photo.

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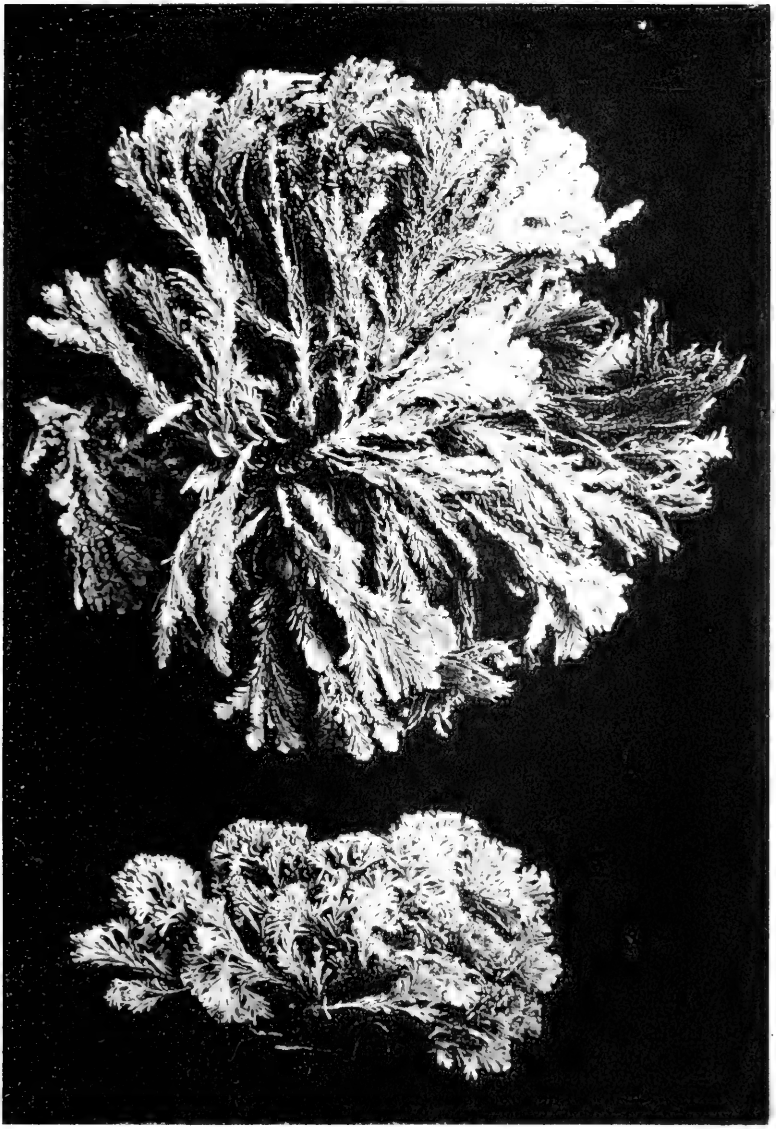

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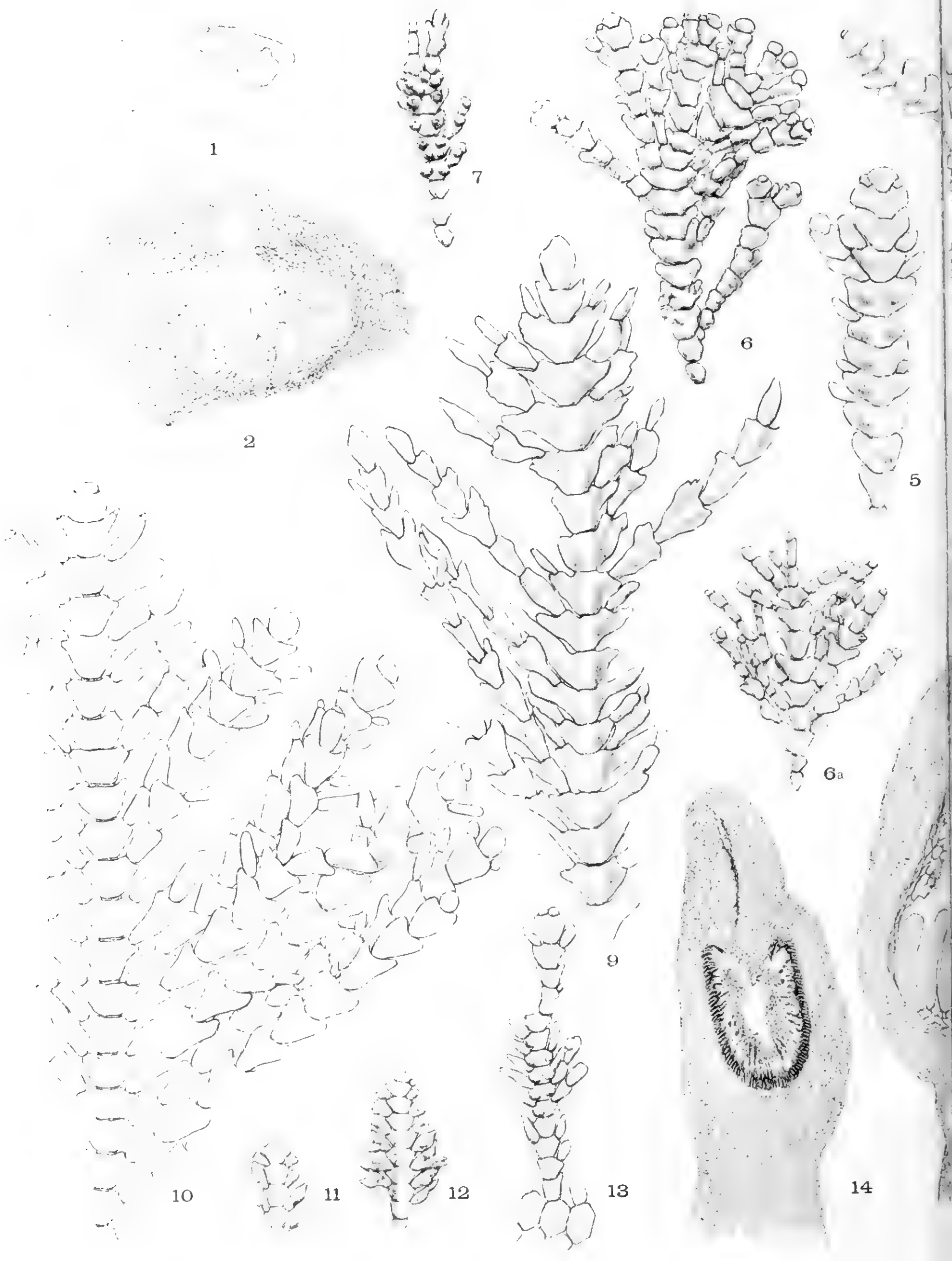

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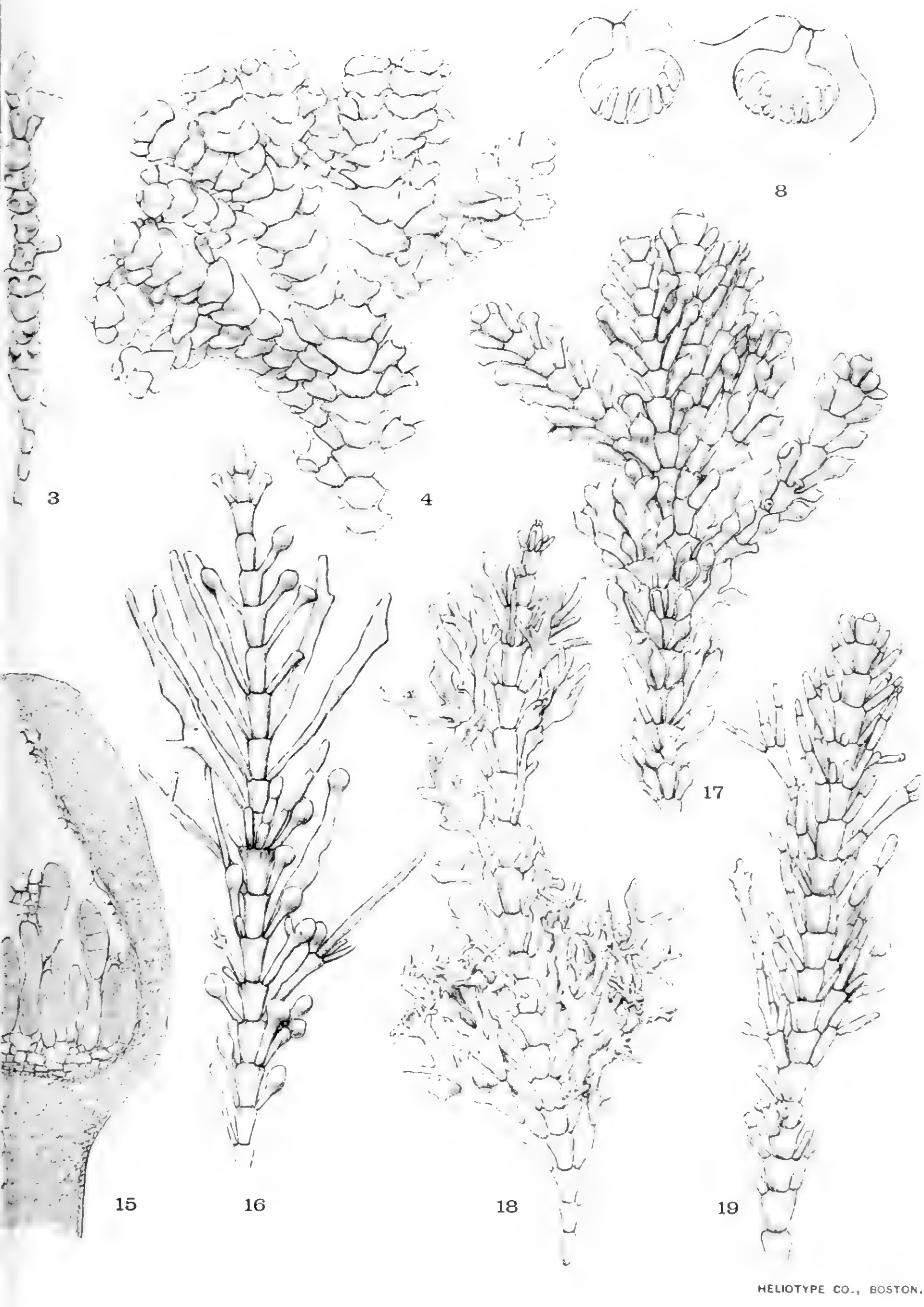


HELIOTYPE CO., BOSTON.

XLI. OBSERVATIONS ON PTERYGOPHORA.

CONWAY MACMILLAN.

Among the larger and less thoroughly studied kelps of the Pacific coast, *Pterygophora californica* Ruprecht has seemed worthy of some attention. A fine series of specimens was secured during the summer of 1901 at the Minnesota Seaside Station on the west coast of Vancouver Island, and while all points in the anatomy and life-history cannot be elucidated from the material in hand, it has seemed best to present an account of such structural and developmental facts as have been observed.

The name, *Pterygophora californica*, appears for the first time in botanical literature in Ruprecht's Algen-Stämme,* in 1848. In this work no description is given of the genus and species, Ruprecht contenting himself with the statement that the new genus is intermediate between *Capea* (*Ecklonia*) and *Alaria*—a point of view which has been but slightly modified by later study—and that it will be elsewhere described. In this work, however, there is given some account of the anatomy of the stem and the characteristic annular structure seen in the cross section is mentioned in the following phrase: "Alle (zuweilen bis 9) Ringe deutlich und gleich stark sind." It is in this paper, also, that Ruprecht announces the presence of mucilage ducts in *Pterygophora*, an observation which has since been questioned by Areschoug.

The formal description of *Pterygophora californica*, together with a plate which leaves something to be desired, is presented by Ruprecht in his "Pflanzen aus dem nördlichen Theile des Stillen Oceans," † published four years later. The specimens upon which the description of Ruprecht was based were col-

* Ruprecht, F. J. Bemerkungen ueber den Bau und das Wachsthum einiger grossen Algen-Stämme. Mem. Acad. Imp. Sci. Nat. Petersb. 6: 64, 70. 1848.

† Ruprecht, F. J. Neue oder unvollständig bekannte Pflanzen aus dem nördlichen Theile des Stillen Oceans. Mem. Acad. Imp. Sci. Nat. Petersb. 7: 17–19 (73–75). *t. 5, 8.* 1852.

lected by Wosnessenski in the vicinity of "Ross" (that is, near San Francisco) on the coast of California in July, 1840. The material communicated to Ruprecht comprised some middle-sized plants and some younger specimens, but did not, apparently, enable him to see either the sporelings and unilaminate stage or the mature, full-grown form. Consequently his measurements need modification and the specific description should be revised to include much larger plants. Anderson is the only one who has written on the plant in whose account a knowledge of full-sized plants is indicated. In his Natural History of Santa Cruz county * it is stated that the stem is from one to six feet in length and that the leaves are from one to five feet long, "all without a midrib except the central one into which the flattened stem seems to be lost, giving it the look of a midrib."

It was from Anderson that Areschoug received his specimens of *Pterygophora* upon which, together with those of Ruprecht sent him from the collections of the Academy at St. Petersburg, he based his brief study as set forth in Observationes Phycologicæ.† In this paper Areschoug gives in compact form the generic and specific description and adds some observations and corrections to the earlier account of the Russian botanist. Areschoug observes that the number and nature of the growth-rings in the trunk seem difficult to define. He is skeptical concerning the lacunæ muciferæ, although he retains in his revised description of the genus the phrase "ad peripheriam internam annuli intimi collocata, interdum biseriata," crediting the observation to Ruprecht. He reëxamined the younger specimens upon which Ruprecht's original account was based and gives a condensed description of them. The youngest plant seen appears to have had a stipe 20 cm. long and 2–5 mm. broad with a lamina 35 cm. long and 6–7 cm. broad. As will be seen later my own plant, "B", indicates that these measurements, based upon dried material, need correction. Areschoug received material from "Vera Cruz," California (meaning *Santa* Cruz), sent him by Dr. Anderson and notes, doubtless upon the authority of Anderson, that the plant grows also at San Francisco. In

* Anderson, C. L. The natural history of Santa Cruz county, Oakland, Cal., 24. No date. (1892?)

† Areschoug, J. E Observationes Phycologicæ, Part 5: De Laminariaceis Nonnullis, 11. 1884.

Anderson's List of California marine algæ,* *Pterygophora californica* is recorded as "common or occasional to all the California coasts." The southernmost record of its occurrence that I have happened to find is in Orcutt's Flora of Southern and Lower California.† The plant is here credited to San Diego, based upon collections by Daniel Cleveland. The northernmost point from which specimens have been taken seems to be Port Renfrew, Vancouver Island, B. C., giving the plant a range of over 16° of latitude. It very probably, however, extends up the Alaskan coast. In some observations upon the distribution of *Pterygophora*, Setchell ‡ notes that the characteristic Laminarieæ, Agarieæ and Alarieæ of the North Pacific "stop at about Puget Sound which is the terminus of the isothere of 15°, but *Costaria turneri* Grev. and *Alaria esculenta* (L.) Grev. continue to Monterey, nearly to the 20° line, although they are found only at 'exposed points.' . . . An interesting case is that of *Pterygophora californica* Rupr. which is reported by Dr. C. L. Anderson as growing at Monterey all the year round, but is reported by Mr. Daniel Cleveland as occurring at San Diego only from February until May and in deep water." This statement seems to be based upon the account of *Pterygophora* given by Hervey § in his Sea Mosses in the preparation of which he had the assistance of Dr. Anderson. *Pterygophora*, therefore, seems to have a somewhat wider range than the majority of the North Pacific Laminariaceæ. The plants collected at Port Renfrew were so abundant and robust that I am inclined to think that the region of maximum development may be along the British Columbian rather than along the Californian coast. Ruprecht's plants were Californian; those of Areschoug were from the vicinity of Monterey, as was also the specimen of Hervey: the specimens of Cleveland from San Diego do not seem to have been recorded as of unusual size. The plants of Port Renfrew, some of them with trunks nearly three inches in diameter and eight feet in length, exceed the recorded measurements and indicate thus a particularly luxuriant growth in that

* Anderson, C. L. List of California marine algæ, with notes. Zoe, 2: 220. 1891.

† Orcutt, C. R. Flora of Southern and Lower California, 13. 1885.

‡ Setchell, W. A. On the classification and geographical distribution of the Laminariaceæ. Trans. Conn. Acad. 9: 370. 1893.

§ Hervey, A. B. Sea Mosses. A collector's Guide and an introduction to the study of marine algæ, 88. 1881.

region. The measurements given by different authors are as follows: Ruprecht (l. c.), stipe 6–9 inches long, laminæ up to 2 feet long; Areschoug (l. c.), stipe 30 cm. long, lamina up to one meter in length; De Toni,* stipe 30 cm. long, lamina up to one meter in length (measurements evidently quoted from Areschoug); Hervey (l. c.), stipe 2 or 3 feet long, lamina 2 feet or more long; Setchell (l. c.), stipe 1 to 2 feet long, measurement of leaves not given; Anderson (l. c.), stipe 1 to 6 feet long, lamina 1 to 4 feet long. Of these measurements, Anderson's is the only one that is approximately correct for the average plant as observed on the Straits of Fuca.

The first specimen of *Pterygophora* seen on the Vancouver coast was a battered and eroded stem which had been cast up by the tide. It was between six and seven feet in length and 2.5 inches in thickness near the base. Later another specimen, not quite so large, was extracted from a pile of wrack at the head of a little cove and this had a few dilapidated leaves still attached. Examination of the shore yielded several specimens, some of which were in an excellent state of preservation, but a few days later some growing beds were discovered and the plant was observed in more detail. Its selection of an habitat is interesting. A favorite place for its development seemed to be on the bottom of deep, narrow chasms in which there was from twelve to fifteen feet of water at low tide. It occurred abundantly on the bottom of a circular hole communicating with the sea by a narrow deep inlet and exposed to heavy surge. It was afterwards found that this was its characteristic position and that it habitually came closer to the rocks than either *Nereocystis* or *Macrocystis*. It preferred stations where the water was constantly in motion and did not seem so abundant in quiet coves. As a surge plant it grew lower than *Lessonia* and it may, perhaps, be described as occupying the lowest position of the surge kelps along this coast. To this precise locality the plant shows certain structural adaptations. The holdfast is massive, enabling it to cling firmly to the rocks, notwithstanding the strong movement of the sea. The stem is exceedingly stout—being indeed one of the strongest algal structures known—and is capable of resisting great tensile strain. While not particularly elastic it is bent from side to side without difficulty or damage to its structure. The

* De Toni, J. B. Sylloge Algarum, 3: 352. 1895.

long leaves, often as many as forty in the tuft, hang down beside the stem and as the plant bends from side to side they are swept along the bottom, thus accounting for the erosion of their ends so characteristic of this species. The central lamina is invariably eroded, and only the younger and shorter pinnæ are perfect, all the older ones having lost their tips through the constant brushing back and forth on the rocky bottom. The relative lengths of the leaves and of the stem are regulated by this habit of the growing plant and where the surge was most violent plants were to be found with comparatively long stems and short leaves, but where the surge was less violent the leaves and stem were more nearly the same length, or the leaves might some of them even exceed the stem.

The general appearance of young *Pterygophora* plants as seen upon the bottom is not unlike that of *Nereocystis*. Their attitudes with the erect stem and the dependent leaves are very similar. The older *Pterygophora* plants, from their much more massive stem and shorter leaves, can be distinguished at a glance.

In order to collect an abundant series of *Pterygophora californica* use was made of a tool which may be described as a combination of chisel and hook on the end of a long slender pole, by which the holdfasts were cut and the plant dragged to the surface. In this way a sufficient quantity of material was obtained from which four plants of different ages are selected for description.

Plant "A." This is the youngest specimen seen. It measures 12 mm. in length, of which the stipe and primitive disk constitute but 2 mm., the rest being lamina. In this plant the lamina is already eroded distally. It measures 5 mm. across at its broadest part and narrows down abruptly to the stipe, which is 5 mm. in diameter. The primitive disk, almost exactly circular in shape, measures 2 mm. in diameter. At first the growth of the stipe in length is decidedly slow, but when the lamina has become about 20 mm. in breadth the stipe begins to elongate. In plants under 30 mm. in length the poorly defined midrib of *Pterygophora* has not begun to develop and the lamina seems perfectly homogeneous throughout. In this respect the plant is in marked contrast with *Alaria* sporelings, for in them the midrib will have already strongly developed in plants of corresponding size. The young forms of *Pterygophora californica* show the characteristic shape and developmental sequence of the Laminariaceæ, resembling particularly young plants of *Laminaria saccharina*.

Plant "B." This specimen was collected by Mr. K. Yendo and was kindly presented to me by him. It is apparently of about the same age as Ruprecht's youngest plant. The whole plant is 35 cm. in length, of which 10 cm. is holdfast and stipe, and 25 cm. lamina. The lamina is 8 cm. in breadth at its broadest part. The tip is eroded, as usual, and in this particular specimen the margin is imperfect. The stipe is 8 mm. in diameter, 3 cm. below the base of the lamina, and 5 mm. in diameter just above the holdfast, where it is circular in cross-section. It is, however, elliptical in cross section near the base of the lamina, the stipe being flattened in the plane of the lamina. In this specimen the midrib is beginning to differentiate and is well-marked for a distance of 5 cm. above the base of the lamina and faintly marked for 10 cm farther towards the tip. Distally it quite disappears. Certain hapteric outgrowths are decidedly long and slender in this plant—much more developed than ordinarily.

In plant "B," less than 1 cm. below the base of the lamina, are seen two small emergences, opposite each other on the sides of the stipe. These are the growing points destined to produce the first pair of pinnæ.

Plant "C." This is a somewhat older individual in which twelve pinnæ have been developed. The whole plant is 45 cm. in length from the holdfast to the eroded tip of the central lamina. From the holdfast to the lowest pinna is 15 cm. In this plant the four lower pinnæ are of a deep chocolate brown color and very much eroded and perforated. They present some points of anatomical interest as will be indicated later. The upper pinnæ are olive brown in color and the four uppermost have perfect tips, characteristically rounded, giving to the whole young pinna a distinctly spatulate shape. In texture these young pinnæ in the fresh plant are quite unlike the sporophylls of *Alaria* with which they have been compared. To the touch they feel not unlike thin sheets of celluloid. The central lamina has a more leathery feel, like *Laminaria* or *Lessonia*.

In this plant the stipe is 8 mm. in diameter, midway between the holdfast and the pinnæ. In the region of pinnæ it is decidedly flattened, measuring 9 mm. in width by 3 mm. in thickness. The pinnæ do not stand always directly opposite each other, although this in general is their position. Abortion of one pinna of the pair may be observed in this plant at two points. The base of the pinnæ is more attenuate than that of the central lamina. The holdfast is partly cut away, but is flattened out and compacted much more than in plant B.

Plant "D." This plant was collected in July, preserved in formalose, and brought to Minneapolis for study. It was found growing with several others about twelve feet below the surface of the water at low tide. The stipe from the holdfast to the lowest pinnæ is 2 meters in length. From the lower pinnæ to the base of the central lamina is 1 dm. while the central lamina is 1.5 meters in length. On each side of the stipe, extending along its margin for a little less than a decimeter, are the tufts of lateral pinnæ, twenty on each side. The longest pinna with uneroded end measures 1 meter, but pinnæ with eroded ends are present, 1.5 meters in length. The breadth of the central lamina is 1 dm., the midrib being 4 cm. broad. The broadest pinna measures 7.5 cm. from margin to margin. All margins of full grown pinnæ are undulate. This character is especially marked in the central lamina. One difference between a plant of the age of "D" and a younger form such as "C" lies in the distance between the adjacent pairs of pinnæ. In plant "C," for example, the upper pinnæ are three cm. apart along the stipe and this character is also indicated in Ruprecht's plate. In an older plant, such as "D," the pinnæ are very much crowded together, so much so, indeed, that they crowd each other out of a strictly marginal position. The fully developed pinnæ, in "D" are all massed within a linear distance of 5 cm., while in "C" they are distributed over twice as much space.

The stipe in this specimen is 5 cm. in diameter, 2 dm. above the holdfast. Near the holdfast it is 1 dm. in diameter. Nearer the pinnæ it becomes flattened in cross section, first appearing as elliptical, then as lenticular, the edges becoming sharp 2 dm. below the lowest pinnæ. Along the sharp edges the scars of pinnæ which have been sloughed off are abundant. The stipe in the region of pinna attachment is 3 cm. broad and 7.5 mm. thick. The stipes of the full-grown pinnæ are 4 mm. in diameter and the base of the central lamina is 1 cm. broad and 3 mm. in thickness. A transsection through the stipe of this plant shows 24 concentric rings of growth not all of which were of equal thickness. The pith at the center has the lenticular outline characteristic of arborescent Laminariaceæ and was 8 mm. by 2 mm. in cross section. The pith occupies a greater portion of the cross section nearer the region of pinnæ. Just below the pinna scars a cross section showed it to be 3 cm. in length by 3 mm. in width.

From the measurements of this plant, by no means the largest seen, it becomes apparent that the size of *Pterygophora californica* has been much underestimated, previous descriptions of it having been made from immature material. There seems to be no reason to doubt that this plant is perennial. It gives every structural indication of persisting for a series of years and replenishing its pinnæ with the recurring seasons. Its massive stipe and the base of the central lamina survive the winter storms and in the spring fresh pinnæ are produced and the central lamina is extended by the well-known basal growth characteristic of the family to which it belongs. In this way, doubtless, very large plants may develop. There is one fragment in our collection comprising the pinna region of a plant which by comparative measurements must have been four meters or more in length. The flattened stipe between the pinnæ is 6 cm. broad and the base of the central lamina measures 3 cm. in width.

The relation of the genus *Pterygophora*, to the other genera of the Laminariaceæ has been a matter of some uncertainty. Ruprecht regarded it as intermediate between *Ecklonia* and *Alaria*. Agardh* associates *Pterygophora* with *Alaria*. Areschoug takes it up between *Lessonia* and *Ecklonia*, but this perhaps can scarcely be regarded as an expression of his opinion regarding its true position. By the older systematists the genus has been connected closely with *Laminaria* and it occupies a position next to *Laminaria* in De Toni's Sylloge Algarum and also in Kjellman's Laminariaceæ (l. c.) where *Pterygophora* is placed between *Laminaria* and *Ecklonia* in Tribe VI., Laminarieæ. Setchell (l. c.) connects the genus with *Alaria* under the Tribe Alariideæ. The mid-lamina of *Pterygophora* is strongly suggestive of certain species of the genus *Laminaria*, so much so that when Areschoug described *Laminaria*

* Agardh, J. G. De Laminarieis, Lund Univ. Arsskr. 4: 1.

japonica,* Agarth † suggested that the type specimen was nothing other than a mid-lamina of *Pterygophora*. While this notion of Agardh's was incorrect, a comparison of specimens or reference to Suringar's‡ plate of *Laminaria japonica* will make it clear how natural might have been such a supposition on his part. One also finds in the genus *Laminaria* forms suggesting the pinnate disposition of laminæ in *Pterygophora*. Such a plant is figured and described by Kjellman§ under the name of *Laminaria radicosa*. In this plant lateral outgrowths occur upon the stipe below the lamina in quite the same position in which they are developed in *Pterygophora*. They are not, however, functional as additional laminæ, nor do they particularly increase the photosynthetic vigor of the plant. *Laminaria radicosa* may, nevertheless, be regarded perhaps as showing a transition to the type of *Pterygophora*.

There are some objections to the classification of *Pterygophora* with *Alaria*. Among these, the character of the young plant should be given weight. In *Alaria* the midrib is differentiated at an early stage and is exceedingly distinct in plants only two centimeters in length, while in *Pterygophora* plants 35 centimeters in length show the midrib but indistinctly in the basal portion of the lamina. Anatomically *Pterygophora* conforms to the type of the Laminarieæ in the general character of its tissues, differing in some marked particulars from *Alaria*, although resembling the latter in absence of mucilage canals—structures which are present in most species of *Laminaria*. The distinction of outer and inner cortex which is not always to be made out in *Alaria* is very clear in *Pterygophora*. Upon the whole there would seem to be little objection to the classification of *Pterygophora* in the tribe Laminarieæ. Taking everything into account, however, it will perhaps be best to consider the genus as transitional between the Laminarieæ and the Alariideæ.

An examination of the anatomy of *Pterygophora* seems further to strengthen the view of its close relation to *Laminaria*, while the differentiation of its organs no doubt makes it readily

* Areschoug, J. E. Phyceae Capenses, 29.

† Agardh, J. G. Proc. Soc. Phys. Lund. Bot. Notiser, 1883: 108. 1883.

‡ Suringar, W. F. R. Algae Japonicae, *pl. 11*. 1870.

§ Kjellman, F. R., and Petersen, J. V. Om Japans Laminariaceer. Ur Vega-Expeditionens Vetensk. Iakttagelser., 4: 259, *pl. 10*. 1885.

comparable with *Alaria*. The structure of the stipe differs decidedly from that of *Lessonia* which I have previously examined.* In both genera there are strongly marked growth-rings which, as will be seen, do not arise in precisely the same way. A detailed account of the anatomy follows. From it some notion may be derived of the histological interrelation of *Pterygophora*, *Laminaria* and *Lessonia*.

The most important literature on the anatomy of the Laminariaceæ has been previously cited † and it will not be necessary to refer to it further at this time except as some particular point may require elucidation. To the papers of Wille, Grabendörfer, Reinke, Rosenthal, Oliver, Ruprecht and others students are indebted for researches which have laid the foundation for a knowledge of the anatomy of the Laminariaceæ.

The holdfast.—The study of this structure as of the other organs of *Pterygophora* is based upon a series of slides prepared from material collected at the Minnesota Seaside Station, killed in chromic acid, and transferred into 70 per cent. alcohol in which condition it was brought to Minneapolis for study. Most of the sections have been cut freehand, treated with various reagents and stains and mounted in glycerine-jelly. Russow's callus reagent, chlor-zinc iodide and a variety of stains, including particularly the fuchsin and iodine-green combination and aniline water safranin, have been employed to bring out details of structure.

The primitive disc shows no points of special interest, not differing particularly in structure from that already described for *Nereocystis*,‡ nor at first do the hapteric branches in their origin and structure show characters worthy of especial comment. The haptere originates through the activity of a circular cambial area at the edge of the primitive disc or from the lower rhizogenous area of the stipe. Callosities on the stipe, such as those described for *Nereocystis* and there believed to be equivalent to hapteric branches, have not been discovered in *Pterygophora*, though on one specimen some curious gall-like swellings, doubtless teratological or pathological in their nature, were observed. The numerous hapteric outgrowths of *Ptery-*

* MacMillan, C. Observations on *Lessonia*, Bot. Gaz. **30**: 318. *pl. 19–21.* 1900.

† MacMillan, C. l. c.

‡ MacMillan, C. Observations on *Nereocystis*, Bull. Torr. Club, **26**: 273. *pl. 361, 362.* 1899.

gophora branch dichotomously and build a strong holdfast resembling that of *Lessonia* rather than that of *Nereocystis*. Each young hapteric branch, in cross section, shows the characteristic structure, a great central mass of parenchymatous tissue surrounded by an ill-defined cortical area with an hypodermal cambium. No pith is present and the growth in length and thickness of the hapteres proceeds solely by cambial activity. In older holdfasts distinct growth-rings appear—something that was not seen in the holdfasts of *Lessonia*, and seems not to occur in the hapteric branches of *Nereocystis*, the individuals of which are shorter-lived. The appearance of these rings of growth in the secondary cortical tissues of the holdfast seems to be due rather to rhythmic changes in the character of the cell contents than to regular successions of larger and smaller cells, concentrically arranged. As will appear, this character serves to distinguish to some extent between the growth-rings of the holdfast and of the stipe. In both organs the elements of the secondary cortex are arranged in extremely regular rows, as seen in cross section. This regularity of arrangement does not extend to the primary parenchymatous tissue of the hapteric branch, so that the appearance of a cross section of the older hapteres may be described as follows: At the center is a large more or less circular group of parenchymatous elements regularly hexagonal in outline, varying in size between rather narrow limits. Towards the periphery this central tissue imperceptibly merges with the secondary tissue, the cells of which become more quadrate in outline and assume the characteristic position in rows which can be followed without break directly to the cambial zone which lies near the periphery of the organ. In the secondary tissue there are numerous rings of growth and the cross section of an old haptere, a centimeter or more in diameter, looks not unlike a section of stipe, save for the absence of the characteristic lenticular pith. This is altogether wanting in the hapteres. The growth-rings do not, however, appear to arise consistently through quite the same anatomical conditions as those of the stipe. Well-marked rings in the holdfast may exist without difference in the size of the elements of which they are composed. The optical appearance, therefore, is in all hapteres examined determined by difference in the cell contents. A zone of cells will be formed in which the contents seem to be more dense. Outside a zone, in which the contents are less dense, will appear, and this alternation continues even into the cambial zone where single layers of cells will be found with the denser contents alternating with layers showing the opposite appearance. Besides this difference others have not been discovered to account for the ringed appearance of old hapteres.

As to the substance in the cells which by its greater density gives the ringed appearance it does not seem to differ from the material which has been studied by a number of observers, especially in the Fucaceæ. It has been described by Reinke * as a fatty oil, in which view Hansen † practically coincides and considers that the Phæophyceæ in general produce fat instead of starch by their assimilation. The same material, however, has been described as Phæophyceenstärke by Schimper, as fucosan by Schmitz and Hansteen, as showing a tannin reaction by Berthold, as phloroglucin-containing material by Bruns, as connected with physodes by Crato and as polysaccharids, in constitution allied to mucine, by Koch. In the holdfast of *Pterygophora* the material sometimes fills the whole cell with a homogeneous refringent mass, which in the denser parts of the ring has decidedly the same appearance optically that is shown by the polysaccharid granules of the lamina and stipe to be described later. In other instances the refringent bodies may be distinguished from a generally granular protoplasmic slime which encloses them. Without going into the disputed question of the true chemical character of the cell-contents of Laminariaceæ, it may be said that the ringed appearance of hapteric branches in *Pterygophora* is due to the alternately more vigorous and less vigorous production of certain substances connected with the assimilative processes of the plant. These substances occur in the stipe and lamina as well as in the hapteres, but are there not invariably the cause of a ringed appearance, being disposed in special cells without any apparent reference to the rhythm of secondary growth.

The stipe.—Sections were taken first from plant "B," the unilaminate stage and then from mature plants. In none of them could the mucilage ducts of Ruprecht be discovered and

* Reinke, J. Beitraege zur Kenntniss der Tange. Pringsh. Jahrb. für wissensch. Bot. 10: 317. 1876.

† Hansen. Ueber Stoffbildung bei den Meeresalgen. Mitth. Zool. Stat. Neap. 11: 276.

Pterygophora may safely be described as devoid of these canals. The cross section of a young stipe shows the characteristic lenticular pith-web, composed of anastomosing filaments with numerous trumpet hyphæ intermingled. Chloroplasts are abundant in this tissue and occur more or less sparingly in the perimedulla. Surrounding the pith one finds the cells of the cortical tissue very regularly hexagonal in shape, arranged in remarkably perfect radial rows and diminishing gradually in size towards the periphery. Chloroplasts are absent from most of the cells of this tissue, but appear again, in the smaller cells near the periphery. At about the depth at which chlorophyll becomes abundant the tissue is lacuniferous and the outer cortex readily separates from the inner. The cells of the outer cortex are generally not hexagonal, but cambial conditions cause them to assume the rectangular outline in cross section. The small densely colored cells of the epidermis and hypodermis are uniformly quadrangular. Longitudinal sections through material of this age show the inner cortex to be made up of prosenchymatous elements not pitted or armed and the walls comparatively thin in the region near the pith, but becoming thicker-walled and beginning to present the pitted structure closer to the periphery. The cells of the outer cortex seem to have a special capacity for dividing transversely and periclinally in young material, but in older stipes they divide radially with equal ease. In mature stipes the extraordinarily regular radial rows of cells seen in cross sections may be observed to originate from rows of cambial cells which have divided radially in the outer cortex and have there established the general radial arrangement of the tissues.

Sections through the mature stipe show a structure of the organ in cross section reminding one very much of the tracheids and their arrangement in the Coniferæ. The pits, however, are not upon the radial faces of the elements, but upon the concentric. The cells are all of about the same size and stand in rows radiating in a most regular fashion from the pith to the circumference. There is often not the slightest difficulty in observing that the appearance of growth-rings is due to the gradual diminution in the diameter of the cells until they have become distinctly flattened, followed abruptly by the production of cells of slightly larger lumina. That is to say, the occasion for the ringed appearance of the stipe is structurally quite comparable with that condition so fully studied in the stems of Coniferæ and woody Dicotyledons. In other instances, however, the rings in the stipe seem to arise quite as in the hapteres.

There is in the stipe of *Pterygophora* a plain distinction between the first or primary structure of the cortex and the secondary structure which is established in the lacuniferous period of growth. It is at this time, during the first year, that the outer cortex readily peels from the inner. Later, with the resumption of growth in thickness, the lacunæ are filled by the radially dividing cambial tissue. The tissue of the first or innermost ring, surrounding the pith, differs in appearance from that of subsequent rings. The cells diminish in diameter towards the periphery of the ring until they have the look of stereome in cross section. In this part of the ring the cells are very strongly pitted, in marked contrast to the inner cells of the primary cortex where the pits are but occasional. All the cells, however, of the secondary cortex as displayed in subsequent growth-rings are strongly pitted. Another distinction between the cells of the innermost ring and those of subsequent rings is that the elements of the first ring are slenderer, more prosenchymatous, almost approaching the fibrous shape peripherally, while the elements of later rings are shorter, more parenchymatous and not at all suggestive of fibrous tissue.

In older stipes the pith web is decidedly solid, in marked contradistinction to this tissue in young material. As the stipe matures the interstices between the elements of the pith web become obliterated by the repeated branching and interlacing of the filaments. The chlorophyll also disappears and the cells become filled with densely granular contents. There remain, however, in even the oldest pith, numerous interstitial passages which, in cross section or longitudinal section, present much the same appearance and are, perhaps, what were mistaken for mucilage ducts by Ruprecht.

A cross section of the mature stipe shows then the following characters. At the center is the solidly interwoven tissue of the pith web. This is surrounded by the clearly marked, sclerenchymatous tissue of the primary cortex passing insensibly into the tracheid-like tissue of the secondary cortex which is arranged in concentric rings, resulting from the succession of elements with larger cell-lumina in apposition upon those with smaller. Outside of the rings will be found the cambial zone in which regular divisions take place in all three planes of space. Exterior to the cambial zone lies a thin outer cortex composed of cells very much smaller than those of the inner area, provided with thick walls and constituting a kind of bark for the trunk. In some material the general cambial zone can be very distinctly seen, ten or twelve cells in thickness and separated from the epidermis by twenty or more layers. Not infrequently the cells at the periphery of a ring of growth have more densely granular contents than those of the general secondary cortex tissue. Thus, occasionally in the stipe there may arise the anatomical conditions which seem to be more normally characteristic of the holdfast. The photographs of different cross and longitudinal sections which are presented will serve to make these points clear where the description is necessarily difficult to follow.

The lamina.—As before stated only the central lamina is provided with a midrib, the pinnæ being quite devoid of such a structure. The midrib of the central lamina arises through an hypertrophy of the cortical tissue, in which the pith-plate does not seem to partake. The general structure of the lamina as seen in cross section does not present many peculiar features, but is much like that already described for other genera. There is on each surface an isomorphic epidermis composed of small quadrate chlorophyll-containing cells, and these merge insensibly into the subepidermal tissue, which in some instances is two or more layers in depth. The cells then become much larger in diameter and the contents less dense. Among these cortical cells occasional very large polysaccharid idioblasts are found, and in the chocolate-colored pinnæ of plant "C," these cells are very numerous and densely packed with spherical bodies, doubtless belonging to the category of reserve carbohydrates. Owing to the nutritious character of such pinnæ, they are very commonly perforated by animals, sometimes giving a colander appearance like that of *Agarum*, and covered with epiphytic and endophytic vegetation, a further study of which should be made. These reservoir cells may perhaps be packed with food materials previous to the production of sori and the polysaccharids utilized in the elaboration of the sporangia and paraphyses. In any event they seem to be emptied of their contents underneath most of the soral areas that I have examined. Within the layer of idioblasts the cortical cells become smaller on each side of the pith plate. This latter is composed of anastomosing filaments with occasional trumpet-hyphæ and does not differ particularly from the same tissue as displayed in the stipe. The cortex of the mid-lamina and of the pinnæ seems to show some fairly constant differences. In the pinnæ the cells are often uniformly larger and the layer of idioblasts is frequently almost continuous.

The sorus.—I do not find anywhere in the literature of *Pterygophora* an account of its fruiting area. The first fruiting material that reached me was collected near Port Renfrew by Miss Josephine E. Tilden during December, 1901. Shortly afterwards Professor Setchell kindly sent me some dried pinnæ collected at Whidby Island, Washington, by Mr. N. L. Gardner, and said to display sori. My observations are made from the fresh material collected by Miss Tilden. The soral patches occur upon the lateral pinnæ and not upon the mid-lamina. In this respect they remind one of the soral distribution of *Alaria;* but while in *Alaria* the entire pinna, except a very small marginal region, is soriferous, in *Pterygophora* the sori form somewhat irregular patches upon both surfaces of the pinna and much of its area fails to develop them. In this respect *Pterygophora* approaches more nearly to *Laminaria.*

The sori are composed of numerous elongated, saccate gonidangia, each bearing from fifty to two hundred spherical gonidia. The gonidangial surface is surmounted by the intermingled paraphyses, averaging half as long again as the gonidangia and their clavate distal ends capped with cuticular masses, suggesting those already described for *Lessonia* and indicating that in this plant, as in *Lessonia*, the cuticular layer does not separate in a plate, as described for *Laminaria* by Thuret and as known to occur also in *Nereocystis*, but divides into individual paraphysal calyptra. Some gonidangia measured indicated an average length of 50 mic. and diameter of 10 mic. The gonidia are nearly 2 mic. in diameter and in a double-stained preparation, made for me by Mr. H. L. Lyon, take Delafield's hæmatoxylin while the paraphyses and cuticular substance take the safranin. The gonidangia and paraphyses stand upon a floor-layer such as is found in all Laminariaceous sori, and their development does not differ from that which has already been described for other genera.

I desire to express my thanks to Miss Josephine E. Tilden for the winter fruiting material which she kindly collected for me and for the series of slides from which most of my description has been made, and to Mr. H. L. Lyon for the photo-micrographs reproduced in plate LXI and prepared by him at my request.

SUMMARY.

1. *Pterygophora californica* grows to a larger size than generally known. Specimens ten feet in length with trunks three inches in diameter have been seen.

2. As displayed in the Straits of Fuca, *Pterygophora* is a surge plant, growing below the zone of *Lessonia* and above that of *Nereocystis*.

3. *Pterygophora* may be classified either in the Laminarieæ or the Alariideæ. Its characters are in many respects intermediate between these tribes.

4. The holdfast shows distinct rings of growth and these in most instances arise, not through morphological differences between adjacent cell-layers, but through differences in the cell contents. The substances, which produced in greater or less amount give the ringed appearance, are regarded as polysaccharids allied to mucine, as described by Koch.

5. The stipe is devoid of the mucilage ducts of Ruprecht and shows distinct rings of growth, due in most instances, to the juxtaposition of a layer of cells with larger lumina, upon a layer with smaller. In some cases the ringed appearance of the stipe seemed to be due to the same condition described for the holdfast.

6. In the cortex of the lamina large polysaccharid idioblasts are abundantly developed. These are most numerous in the pinnæ and are often exhausted of their contents during the process of soral formation.

7. The sori are distributed in irregular patches toward the base of the pinna and in the disposition of the cuticular caps upon the paraphyses suggest *Lessonia*. The plant fruits in the latitude of Port Renfrew during the month of December.

DESCRIPTION OF PLATE LVII.

Young plants of *Pterygophora*, about one-half natural size.

1. Plant "A" of text.

2, 3, 4. Somewhat older plants; in 4 the midrib is just beginning to appear in the base of the lamina.

5. Plant "B" of text; the midrib is more distinct and the two opposite growing points of the first pair of pinnæ may be seen just below the junction of lamina with stipe.

PLATE LVIII.

Plant "C" of text. The plant is shown a little more than one-third the natural size. It presents the loosely arranged pinnæ characteristic of young plants and as shown in Ruprecht's plate. The lower pinnæ are perforated by marine animals and are the ones in which the reserve material is the most abundant. The mid-lamina alone shows a midrib.

PLATE LIX.

Plant "D" of text. The size is indicated by the hat placed in the field of view. It is about one-tenth natural size and was photographed on the shore a few moments after collection. It is somewhat foreshortened, being between three and four meters in length. The central lamina is shown in line with the stipe.

PLATE LX.

Pinna-region of full-grown specimen, one-half natural size. The very much crowded position of pinnæ in old plants is indicated in this plate. Below the pinnæ may be seen scars left by pinnæ of previous seasons.

PLATE LXI.

Cross sections through the stipe, natural size. The lower figure is taken near the base of the stipe, while the upper is cut just below the region of pinnæ. The great difference in the extent of the pith and in its shape, in the two sections, is noticeable. The characteristic rings of growth are apparent in both figures.

Plates LVII. to LXI. are from photographs made under the direction of the author, by Mr. C. J. Hibbard, Photographer of the Department of Botany in the University of Minnesota.

PLATE LXII.

The anatomical detail of *Pterygophora*.

1. Cross section through secondary cortex of stipe, showing rings of growth ($\times$ 50).

2. Cross section through stipe, showing secondary cortex above and primary cortex below ($\times$ 50).

3. Longitudinal section through secondary cortex showing flattening of cells towards the right. This would appear as a ring in the cross section ($\times$ 50).

4. Tangential section through secondary cortex, showing the somewhat fusiform outline of the cells in this section (× 50).

5. Longitudinal section through region of Fig. 3. On the left is seen the tissue of the secondary cortex, in the middle the flattened cells of the transition zone, and on the right the cells of the primary cortex. This first ring of growth, caused by the superposition of secondary upon primary tissue, is the most prominent of all the growth rings in the stipe (× 50).

6. A portion of the secondary cortex tissue shown in Fig. 5, magnified to demonstrate the pits in the vertical walls of the tracheid-like elements. To the right the cells become compressed, passing into the transition zone (× 250).

7. A portion of the primary cortex tissue shown in Fig. 5, magnified to demonstrate the different arrangement of primary and secondary cortical cells. The secondary stand in long rows at the same level. This is not true of the primary (× 250).

8. Cross section through one of the rings shown in Fig. 1 and magnified to demonstrate the flattening of cells in the region of the ring and their denser contents. The appearance of small cells interpolated between the larger ones can be understood by referring to Fig. 4 (× 250).

9. Cross section through pith web of stipe, showing anastomosing filaments and trumpet hyphæ embedded in a gelatinous matrix (× 250).

10. Cross section through haptere. The cells of the outer cortical region are crowded with contents, and do not differentiate clearly. Near the middle of the section are seen two of the characteristic growth-rings of the haptere (× 50).

11. Longitudinal section through haptere, showing the development of secondary tissues, the cells of which are shorter upon the primary tissue towards the bottom of the figure. Below the black outer cortex a growth-ring in section may be seen (× 60).

12. Section through sorus, showing floor-cells, gonidangia with gonidia and paraphyses capped with cuticular knobs characteristic of this genus and of *Lessonia* (× 320).

All the figures in Plate LXII. are from original photomicrographs by Mr. H. L. Lyon.

PLATE LVII.

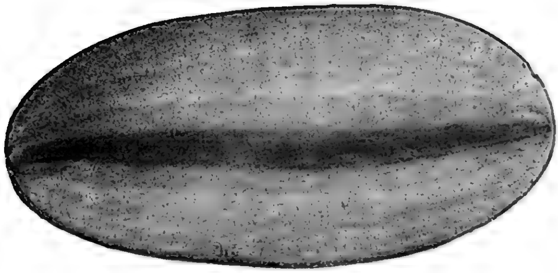
HELIOTYPE CO., BOSTON.

PLATE LVIII.

HELIOTYPE CO., BOSTON.

PLATE LIX

PLATE LX.



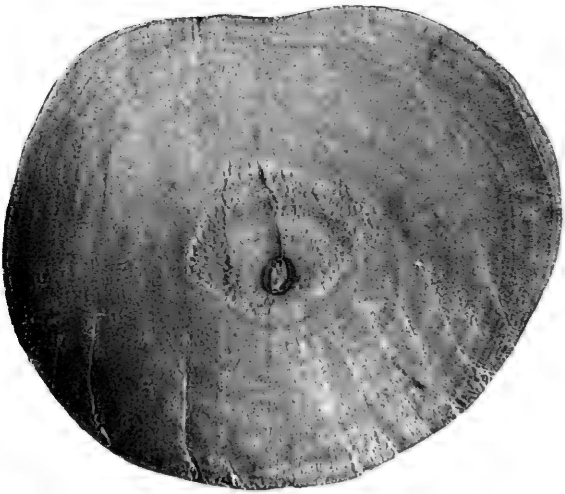


PLATE LXI.

HELIOTYPE CO., BOSTON.

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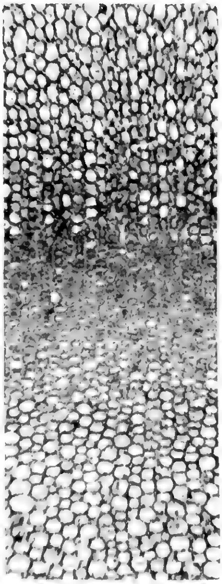

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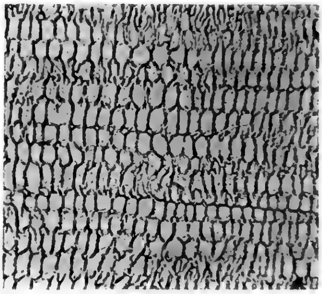

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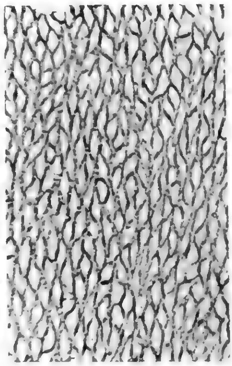

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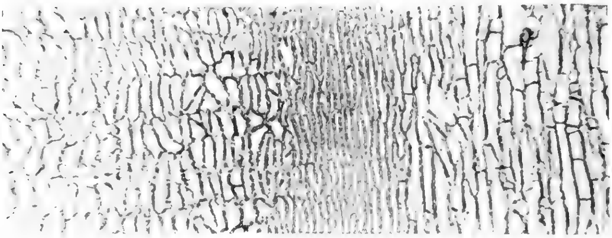

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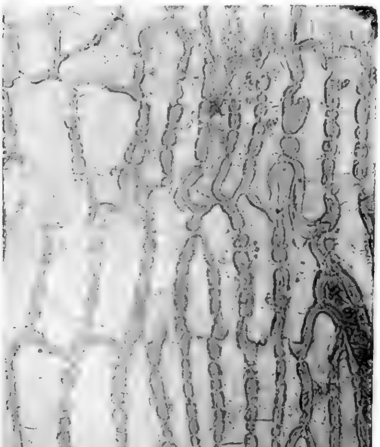

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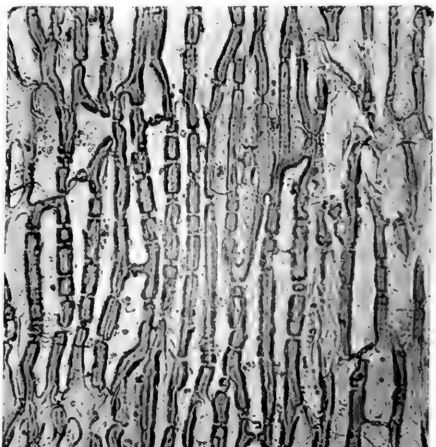

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PLAT

HELIOTYPE

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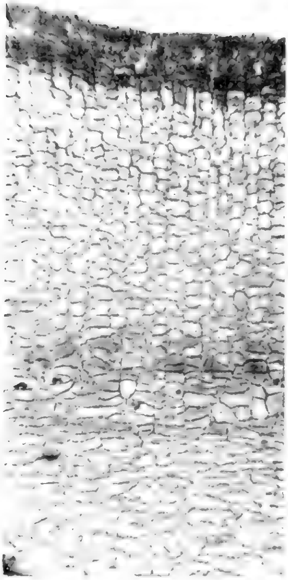

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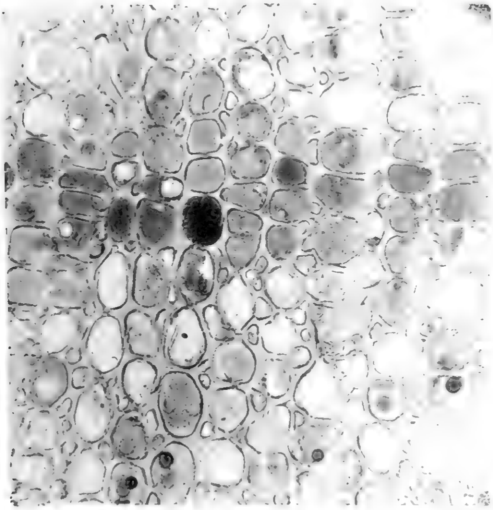

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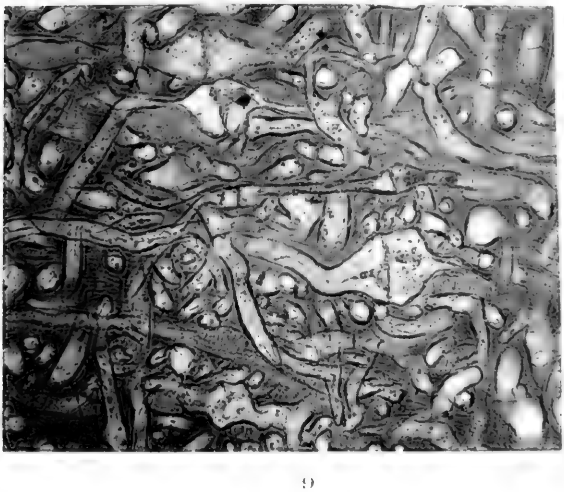

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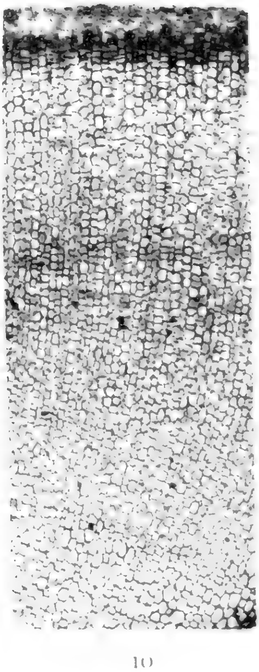

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INDEX OF PLANT NAMES.*

* The index was prepared by Miss Josephine E. Tilden.

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